Jefferson River Watershed Hydrologic Analysis Gallatin and Madison Counties, MT

July 2018

Michael Baker INTERNATIONAL

Document History

Document Location

Location

Revision History

Version Number	Version Date	Summary of Changes	Team/Author
01	04/10/2018	Initial Submittal	R. Anderson
02	07/06/2018	Revision 1 updates figures and adds text regarding watershed delineation of Indian Creek and provides information on analyses performed on Beaverhead River in Twin Bridges reach.	R. Anderson

Client Distribution

Name	Title/Organization	Location

Table of Contents

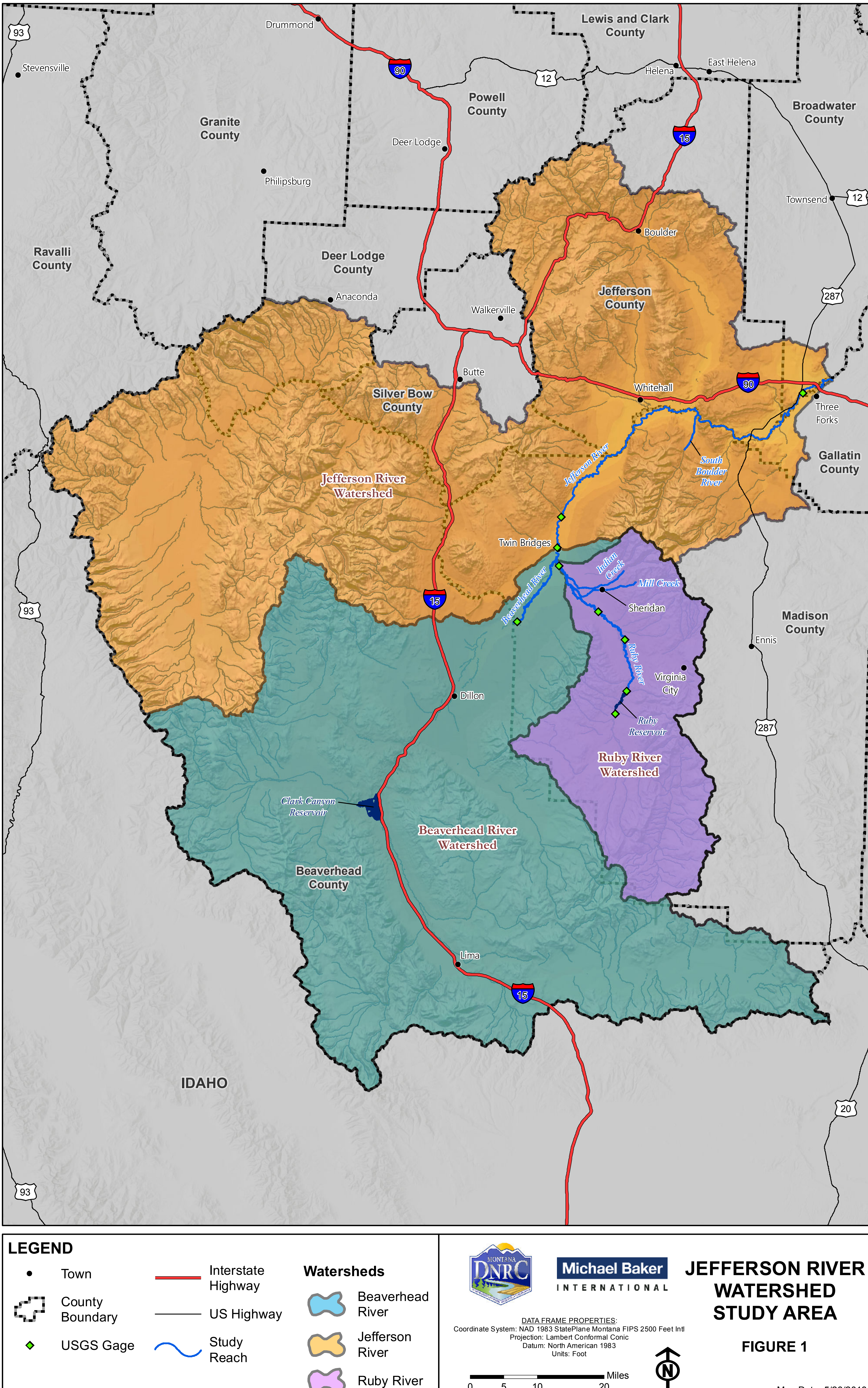
1. Executive Summary

Hydrologic analyses have been performed at USGS gaged and ungaged sites in the Jefferson River watershed. Select stream gages on the Jefferson River, Beaverhead River, and Ruby River were analyzed using at-station and record extension methodologies described in Bulletin 17C. Ungaged sites on Indian Creek, Mill Creek, and South Boulder River were analyzed using regional regression equations. The peak discharge flood-frequency analysis determined the peak discharges for the 10%, 4%, 2%, 1% and 0.2% Annual Exceedance Probability flood events. Additionally, peak discharges were determined for a standard error of prediction above the 1% Annual Exceedance Probability event to demonstrate a level of uncertainty in the computed discharge values, and, ultimately, the calculated flood elevations. For FEMA-based flood risk products, this discharge value above the 1% Annual Exceedance Probability is known as the 1% Plus discharge. For the Jefferson River, the USGS gaging stations at Three Forks, MT and near Twin Bridges, MT were included in the analyses. The Jefferson River analysis used 111 peak flow events in the Maintenance of Variance Extension, Type 3 record extension methodology. The Beaverhead River USGS gaging station near Twin Bridges was only gaging station analyzed in this study, and the at-site peak-flow frequency analysis included 52 peak flow events. Five USGS gaging stations were analyzed on the Ruby River, four below Ruby Reservoir and one above the reservoir. The USGS gaging station above the reservoir was analyzed using the at-site methodology for 78 peak flow events in the flow record at the site. Analyses for the four USGS gaging stations on the Ruby River below the reservoir were performed using the Maintenance of Variance Extension, Type 3 record extension methodology that incorporated 78 peak flow events.

This study revises the peak flow values previously reported in the Flood Insurance Study for the Jefferson River at Three Forks, MT in Gallatin County. The revised peak flow value is less than previously reported and is a result of a substantially longer period of record used in the analysis and more robust statistical analysis methods. This study incorporates peak flow data through 2016 and revises previous analyses performed in a recent USGS flood frequency peak-flow analysis performed on USGS gaging stations with flow data through 2011. In addition to the additional years of flow data, an updated record extension methodology was utilized at most gaging stations in this study. As a result, the calculated flood-frequency peak flow values generally vary a small amount from the analyses on the 2011 flow data. There were no systemic trends to the revised values, as the updated flows include both increases and decreases.

Intermediate flow change locations were identified based on watershed characteristics to account for the features within the watershed that result in the changes in flow as the river flows downstream through the watershed. The flow nodes were located at significant tributaries and other substantial increases in drainage area which can account for flow increases along the river. In addition to the two USGS gaging stations, four flow change locations are included on the Jefferson River. Similarly, along the Beaverhead River, beyond the one gage station location near the Madison County – Beaverhead County line, two other flow nodes are located along the Beaverhead River. Linear interpolation methods based on contributing drainage area were utilized to determine the flow values for locations that are between two gages on the same river. For flow nodes that are near one gage station, gage transfer equations were utilized to determine flow values at these sites. Regression analyses were performed on three drainages within the Jefferson River watershed. These drainages are ungaged tributaries to the larger, gaged rivers. Two of these drainages, Indian Creek and Mill Creek, are tributaries to the Ruby River near the town of Sheridan, MT, and one drainage, South Boulder River, is a tributary to the Jefferson River near Cardwell, MT. The regional regression equations were developed by the USGS and based on regression analyses of stream gaging stations grouped within eight hydrologic regions throughout Montana. The flow data utilized to develop the regression equations included gaged data through 2011, and the regression equations for the southwest region were utilized in this analysis. The regression equations use contributing drainage area (mi^2) and percent of watershed higher than 6,000 ft elevation (%) as the explanatory variables for the flow calculations. These parameters were derived from USGS StreamStats web-based application and modified as necessary following verification of the StreamStats auto-generated output. Flow calculations were performed at two locations within each of these tributaries. The entire watersheds were delineated at the confluence of the tributary to make flow estimates for the entire contributing area. A second delineation was made in each watershed to establish flow change locations at areas of interest along the tributary. For Indian Creek and Mill Creek, the flow change locations are at their respective road crossings at Main Street near the town of Sheridan. These locations provide representative flows to evaluate the flood risk at Sheridan. A flow change location was established on South Boulder River seven miles upstream of the confluence with the Jefferson River near the US Forest Service boundary where South Boulder River exits the confined valley and enters an area with a broader floodplain. Gage and flow node locations with corresponding recommended flow values is contained in Table 4.

The resulting flow values at the gaged sites, ungaged site, and intermediate flow change locations are provided in summary information prepared as part of this study. The flow values were determined using methods that meet FEMA guidance and standards and are considered to be reliable for use in future flood risk products.



JEFFERSON RIVER WATERSHED STUDY AREA

FIGURE 1

2. Introduction

Under contract to the State of Montana's Department of Natural Resources and Conservation (DNRC), Michael Baker International (Baker) has been tasked with preparing a Hydrologic Analysis Report for the Jefferson River and tributaries (Beaverhead River, Ruby River, South Boulder River, Indian Creek, and Mill Creek) within Gallatin and Madison Counties, Montana (Figure 1). The purpose of the hydrologic analyses is to provide new and updated hydrologic information that will be subsequently used in floodplain mapping activities within the Jefferson River watershed. The State of Montana is a Cooperating Technical Partner (CTP) with the US Department of Homeland Security (DHS) Federal Emergency Management Agency (FEMA), and this work is performed under Mapping Activity Statement (MAS) Number 2017-04, Jefferson River Watershed, Phase I.

This hydrologic analyses for the Jefferson River watershed includes the Jefferson River from its confluence with the Madison River near Three Forks, MT upstream to its inception at the confluence of the Big Hole and Beaverhead Rivers; the Beaverhead River (within Madison County); the Ruby River (from its confluence with the Beaverhead River upstream to the stream gage above the Ruby Reservoir, near Alder, MT); Indian and Mill Creeks in the vicinity of Sheridan, MT; and the South Boulder River (Figure 1). Hydrologic analyses for the Jefferson River, Beaverhead River, and Ruby River were performed by updating the peak flow analyses at gaged locations by the USGS. Hydrologic analyses for the South Boulder River, Indian Creek, and Mill Creek were performed using regional regression equations derived from statistical stream gage analyses of various rivers and creeks in similar hydrologic-geophysical settings. This study does not include other tributaries to these flooding sources.

2.1. Background Information and Existing Flood Hazards

As a participant in FEMA's CTP program, The State of Montana works in collaboration with FEMA to identify flood hazards and communicate flood risk to communities throughout the state, and to assist with administration of the National Flood Insurance Program (NFIP). In this role, the State also engages with communities to provide technical and community outreach resources related to implementation of the NFIP, the Montana Floodplain and Floodway Management Act (1971), and the Montana Code Annotated. Annually, the State identifies and prioritizes specific study and mapping projects and applies to FEMA for funding to implement these projects and other related program activities. The hydrologic evaluation of the Jefferson River and tributaries is one element of a project identified and prioritized for the Jefferson River Watershed Phase I study. The ultimate goal of the study is to provide new and updated flood hazard risk information to the communities within the Jefferson River watershed.

Existing flood hazard information within the Jefferson River watershed is quite limited given the broad extent and considerable flood risk posed by the Jefferson River and tributaries. Flood hazard information has been published by FEMA on a Flood Insurance Rate Map (FIRM) for Gallatin County, which includes the area around the City of Three Forks and unincorporated portions Gallatin County along the Jefferson River. (Portions of the Jefferson River in upstream and downstream of Three

Forks is currently mapped as Zone A on the FIRM, while approximately 5 miles of the river immediately adjacent to Three Forks is mapped as Zone AE with floodway. Across the Jefferson River from Gallatin County and Three Forks is Broadwater County, where the Jefferson River is mapped as Zone A on the FIRM. Further upstream, in Jefferson County, effective mapping for the Jefferson River shows Zone A floodplains. Still further upstream in Madison County, there is no effective flood hazard mapping that covers the Jefferson River. Within Madison County, the Town of Twin Bridges has an effective 1986 FIRM that includes Zone A mapping along the Beaverhead River within the town's corporate limits. No effective floodplain mapping exists for the remaining portions of Madison County within the Jefferson River watershed study area, including the Beaverhead River, Ruby River, South Boulder River, Indian Creek, and Mill Creek.

2.2. Basin Description

The Jefferson River watershed drains a substantial portion of southwest Montana, and, along with the Madison and Gallatin Rivers, is one of the three headwater tributaries that forms the Missouri River near Three Forks, MT. The Jefferson River forms at the confluence of the Beaverhead and Big Hole Rivers near Twin Bridges, MT, approximately 60 miles upstream of Three Forks. The tributaries to the Jefferson River drain the continental divide to the west (Big Hole River) and south (Beaverhead River), as well as portions of the Elkhorn Mountains (Boulder River) and the Ruby Range, Gravelly Range, and Tobacco Root Mountains (Ruby River). The Jefferson River watershed at USGS gaging station near Three Forks, MT (USGS 06036650) drains approximately 9,560 mi^2.

From its source near Twin Bridges, the Jefferson River is a relatively low gradient, meandering river anastomosed with multiple flow splits around well vegetated, quasi-permanent islands. The Jefferson River contains broad floodplains, which are inundated during relatively high flows that overtop the streambanks and continue as shallow overland flow. The floodplains have strong connectivity with the Jefferson River through the shallow ground water table present during the spring and early summer peak flows. The major tributaries to the Jefferson River (Big Hole, Beaverhead, and Ruby Rivers) share similar characteristics with the Jefferson River (low gradient, meandering channel, broad floodplains). Only the headwater streams and creeks which feed these tributaries have steep, higher gradient channels characteristic of headwater streams.

Much of the land use adjacent to the Jefferson River and floodplain is classified as agricultural (farming and ranching). While several small farming communities are present along the Jefferson River, the setting is almost entirely rural, with Three Forks having the highest population (approximately 2,000 (US Census Bureau 2016 projected)) followed by Whitehall (approximately 1,100), Twin Bridges (approximately 400), Willow Creek (approximately 200), and Cardwell (approximately 40). The largest community within the Jefferson River watershed is Dillon, MT (along the Beaverhead River) with a population of just under 4,300. US Highway 287, State Highway 55, State Highway 41, and Interstate 90 are the major roadways present along portions of the Jefferson River. These roadways, as well as numerous county roads, city streets, private drives, farm/ranch accesses, and the Montana Rail Link railroad have bridges that cross the Jefferson River.

Several small irrigation systems divert water from the Jefferson River, but these appear to be relatively minor diversions and generally deliver water to farms and ranches within, or very near, the Jefferson River floodplain. There are no impoundments on the Jefferson River, but two major impoundments are located within the watershed: Clark Canyon Dam and Reservoir on the Beaverhead River, and the Ruby Dam and Reservoir on the Ruby River. Clark Canyon Dam was completed in 1964, and the reservoir stores approximately 257,000 acre-ft. The Ruby Dam was completed in 1938, and the capacity of Ruby Reservoir is about 37,600 acre-ft. As noted above, much of the land along the Jefferson River and its tributaries is in private ownership; primarily as farms, ranches, and the businesses and residents of the communities along the rivers. Throughout the remainder of the watershed, however, most of the land ownership is public land - managed primarily by the US Forest Service, Bureau of Land Management, and State of Montana.

The Jefferson River watershed elevation ranges from 4,077 feet above MSL (NGVD29) at USGS gaging station 06036650 (Jefferson River near Three Forks, MT), to over 11,000 feet in the watershed's mountain peaks. The mean basin elevation is 6,750 feet, and 75% of the basin is at an elevation above 6,000 ft. Approximately 33% of the watershed is forested. Annual precipitation varies widely across the watershed, with up to 50 inches per year in the high mountains and as low as 12 inches per year at the Jefferson River valley floor. Based on data collected using USGS StreamStats (McCarthy et al. 2016), mean annual precipitation averaged across the watershed is 19.6 inches per year. Temperatures vary widely across the watershed as well, with wintertime low temperatures frequently dropping well below zero degrees Fahrenheit, and summertime high temperatures average more than 80°F in the watershed's lower elevations (Montana Climate Office).

2.3. Flood History

2.3.1. Jefferson River

Consistent with many river systems in the Rocky Mountain region, peak flows on the Jefferson River and tributaries typically are a function of annual snowmelt and generally occur in the late spring or early summer. As an example, of the 80 years of peak flow records at USGS 06036650 Jefferson River near Three Forks, MT, all the annual peak flow events exceeding the 50% annual exceedance probability (8,490 cfs) occur in May or June. This dominance of spring/summer snowmelt on the annual peak flow record is reflected by other stream gages in the Jefferson River watershed. In addition to flooding from snowmelt, ice jam flooding can be a significant source of localized flooding along the Jefferson River and tributaries. The most commonly reported areas of flooding due to ice jamming on the Jefferson River are in the Twin Bridges area and near Three Forks.

In addition to the USGS stream gage near Three Forks (06036650), there are flow data for the Jefferson River and tributaries (Beaverhead River and Ruby River) from other stream gages in the watershed within the study area. Figures 2 through 4 show the individual sub-watersheds in the Jefferson River watershed, and indicate the location of the stream gages within the Jefferson River watershed project area. Figures 5 through 12 graphically present the peak flow data for the gages used in the statistical analyses, including the period of record at each gage site and the additional years included in those analyses that employed record extension. Table 1 lists peak flow information for the aforementioned gages as well as the largest recorded flood events from the gage record. Note that some stream gages included in Table 1 were not part of the stream gage analyses included in this study.

2.3.2. Beaverhead River

Flood history for the Beaverhead River near Twin Bridges indicates the largest floods were in 1984 (two peaks: 2,200 cfs in June and 1,620 cfs in October), 1995 (1,460 cfs), 1969 (1,370 cfs), and in 1975 and 1976 (1,250 cfs and 1,200 cfs, respectively). The spring 1984 flood event was greater than 100-year event, while the fall event was a 25-year flood event. The other flood events were in the approximately 10-year to 25-year flood events.

2.3.3. Ruby River

In the Ruby River sub-watershed upstream of the Ruby Reservoir, the largest flood events occurred in 1984 (3,810 cfs – greater than 500-yr flood event), 1995 and 1991 (2,060 cfs and 2,040 cfs, respectively – approximately 25-year flood events), and two flood events that were just under the 25-year flood events, occurring in 1997 (1,800 cfs) and 2011 (1,780 cfs). Below the Ruby Reservoir, the largest flood peaks occurred in 1984, 2011, 1995, 1991, 2010. The magnitude of the flow events below the reservoir varied depending on the location (ranging from 3,010 cfs to just over 1,000 immediately below the reservoir and 3,910 cfs to 2,010 cfs near Twin Bridges). All events below the reservoir experienced some attenuation from the reservoir and had recurrence intervals around 200-year at peak event to around 10-year events for the corresponding years. The gage located above the Ruby Reservoir is the only unregulated gage in this Jefferson River watershed study.

Available photo documentation of flood events within the Jefferson River watershed are included in Appendix A.

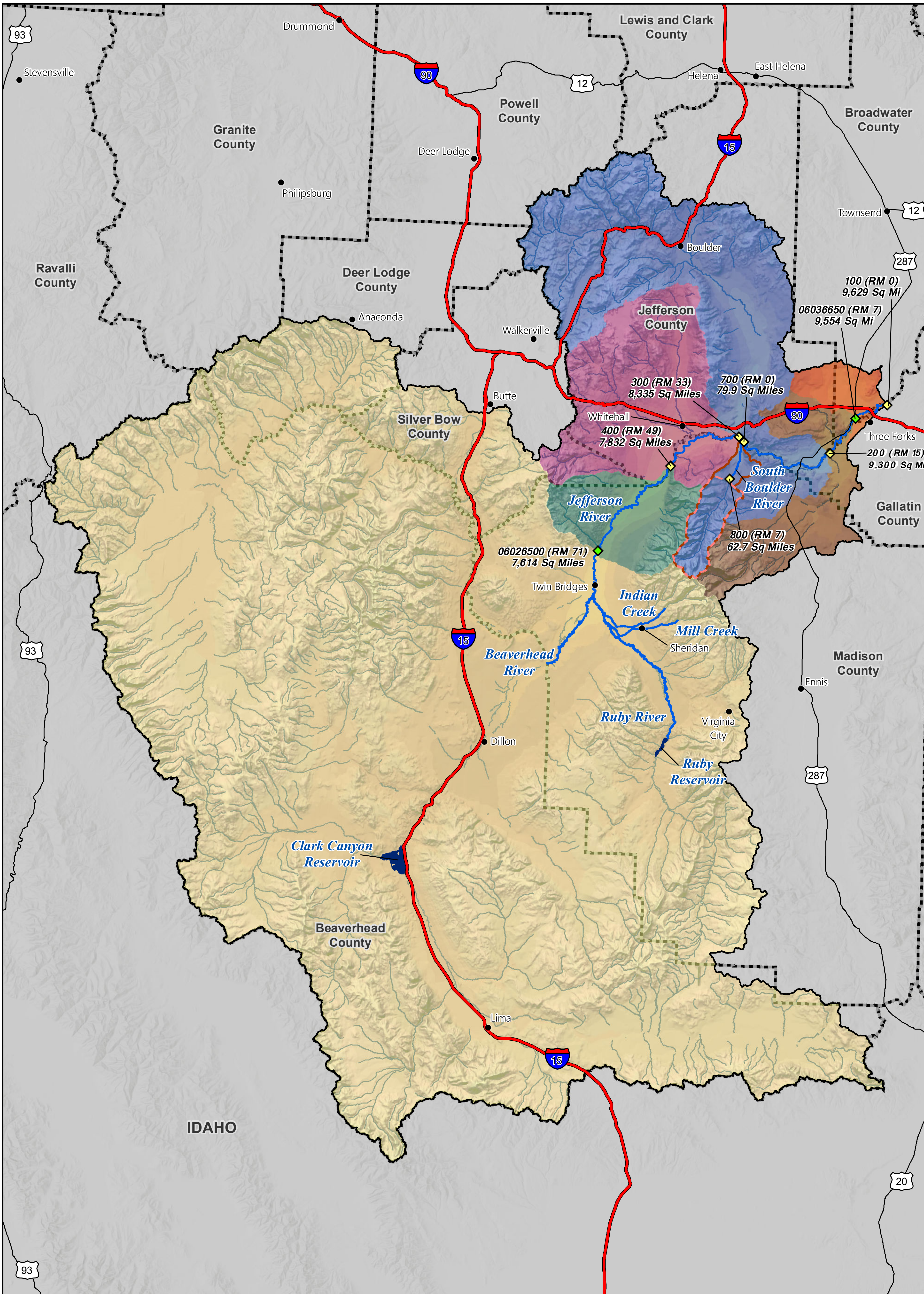
Table 1: Peak flow data for select gages in the Jefferson River watershed.

Jefferson River						
Station Name	Jefferson River near Three Forks		Jefferson River at Sappington		Jefferson River at Parsons Bdg near Silver Star	
Station Number	06036650		06034500		06027600	
Period of Peak Flow Data	1979–2017		1894-1969		2009 - 2015	
Number of Peak Flow Records	39		42		5	
Largest Recorded Events	Date	Peak Flow (cfs)	Date	Peak Flow (cfs)	Date	Peak Flow (cfs)
	6/12/2011	17,400	6/23/1899	21,000	6/11/2011	13,600
	6/9/1995	17,000	6/6/1948	19,900	6/19/2010	12,300
	6/11/1997	16,700	6/12/1964	16,000	6/2/2009	7,820
	5/24/1981	15,900	6/21/1975	15,000	6/4/2015	4,090
	6/24/1984	15,200	5/30/1942	14,500	6/1/2013	2,360
Jefferson River						
Station Name	Jefferson River at Silver Star		Jefferson River near Silver Star		Jefferson River near Twin Bridges	
Station Number	06027200		06027000		06026500	
Period of Peak Flow Data	1973 - 1974		1911 - 1939		1942 - 2017	
Number of Peak Flow Records	2		25		41	
Largest Recorded Events	Date	Peak Flow (cfs)	Date	Peak Flow (cfs)	Date	Peak Flow (cfs)
	6/19/1974	11,500	6/15/1927	20,300*	6/10/1964	16,500
	6/17/1973	3,140	6/15/1913	17,100	6/9/1997	15,200
			6/23/1916	13,500	6/8/1995	14,000
			6/11/1921	13,500	5/28/1942	13,200
			6/11/1922	13,500	6/11/1996	13,100

Ruby River						
Station Name	Ruby River near Twin Bridges		Ruby River bl Ramshorn Cr nr Alder		Ruby River at Laurin	
Station Number	06023000		06022000		06021500	
Period of Peak Flow Data	1942 - 2016		1947 - 1953		1947 - 1960	
Number of Peak Flow Records	25		7		14	
Largest Recorded Events	Date	Peak Flow (cfs)	Date	Peak Flow (cfs)	Date	Peak Flow (cfs)
	6/12/1947	1,500	6/11/1947	1,340	6/11/1947	980
	6/4/1948	1,470	6/4/1948	1,050	6/5/1948	737
	6/22/1964	1,350	6/16/1953	763	6/16/1953	568
	6/12/1942	1,040	6/25/1950	501	5/14/1960	564
	6/8/1981	1,000	6/7/1952	472	6/17/1955	473
Ruby River						
Station Name	Ruby River near Alder		Ruby River below reservoir near Alder		Ruby River above reservoir near Alder	
Station Number	06021000		06020600		06019500	
Period of Peak Flow Data	1929 - 1960		1963 - 2017		1939 - 2017	
Number of Peak Flow Records	24		55		79	
Largest Recorded Events	Date	Peak Flow (cfs)	Date	Peak Flow (cfs)	Date	Peak Flow (cfs)
	6/11/1947	1,380	5/16/1984	3,010	5/16/1984	3,810
	5/31/1948	1,080	6/7/1995	1,820	6/6/1995	2,060
	8/14/1936	965	6/9/2011	1,720	8/26/1991	2,040
	6/15/1953	830	6/10/1970	1,610	6/2/1997	1,800
	5/14/1960	814	6/9/1964	1,530	6/8/2011	1,780

Beaverhead River						
Station Name	Beaverhead River near Twin Bridges MT					
Station Number	06018500					
Period of Peak Flow Data	1936 - 2017					
Number of Peak Flow Records	81					
Largest Recorded Events	Date	Peak Flow (cfs)				
	6/12/1944	3,130				
	6/25/1984	2,200				
	6/26/1948	2,180				
	6/22/1964	1,730				
	6/12/1947	1,710				
***Peak affected by dam failure**						

Based on the stream gage analyses performed by USGS using available gaging data (see Section 4.0 Hydrologic Analyses and Results) and record extension methods, the largest floods recorded on the Jefferson River in the Three Forks area were in 1899 (21,000 cfs), 1948 (19,900 cfs), 1913 (19,100 cfs), and 2011 (17,400 cfs). Based on the flood frequency analyses described in Section 4.0, the estimated recurrence interval of these flood events is on the order of approaching a 100-year flood in 1899, about a 50-year flood for the 1948 and 1913 floods, and approximately a 25-year flood for the 2011 flood. For the Jefferson River near Twin Bridges, the largest flood events occurred in 1927 (20,300 cfs), 1899 (18,700 cfs), 1948 (17,800 cfs), 1913 (17,100 cfs), and 1964 (16,500 cfs). Based on updated flood-frequency results, the 1927 flood event corresponded to about a 200-year flood event. The 1927 flood was attributed to the Pattengill Dam failure on the Big Hole River on June 14, 1927. The 1899 flood event corresponds to about a 100-year flood at Twin Bridges, the 1948 and 1913 events are right around 50-year flood events, and the 1964 flood is between a 25-year and 50-year event.



LEGEND

Flow Change Basin

800 (RM 7)
700 (RM 0)
06026500
400 (RM 49)
300 (RM 33)
200 (RM 15)
06036650
Flow Change Location
USGS Gage
Study Reach
Towns
Counties
Interstate
Highway

MONTANA DNRC

Michael Baker INTERNATIONAL

DATA FRAME PROPERTIES:
Coordinate System: NAD 1983 StatePlane Montana FIPS 2500 Feet Intl
Projection: Lambert Conformal Conic
Datum: North American 1983
Units: Foot

0 5 10 20 Miles

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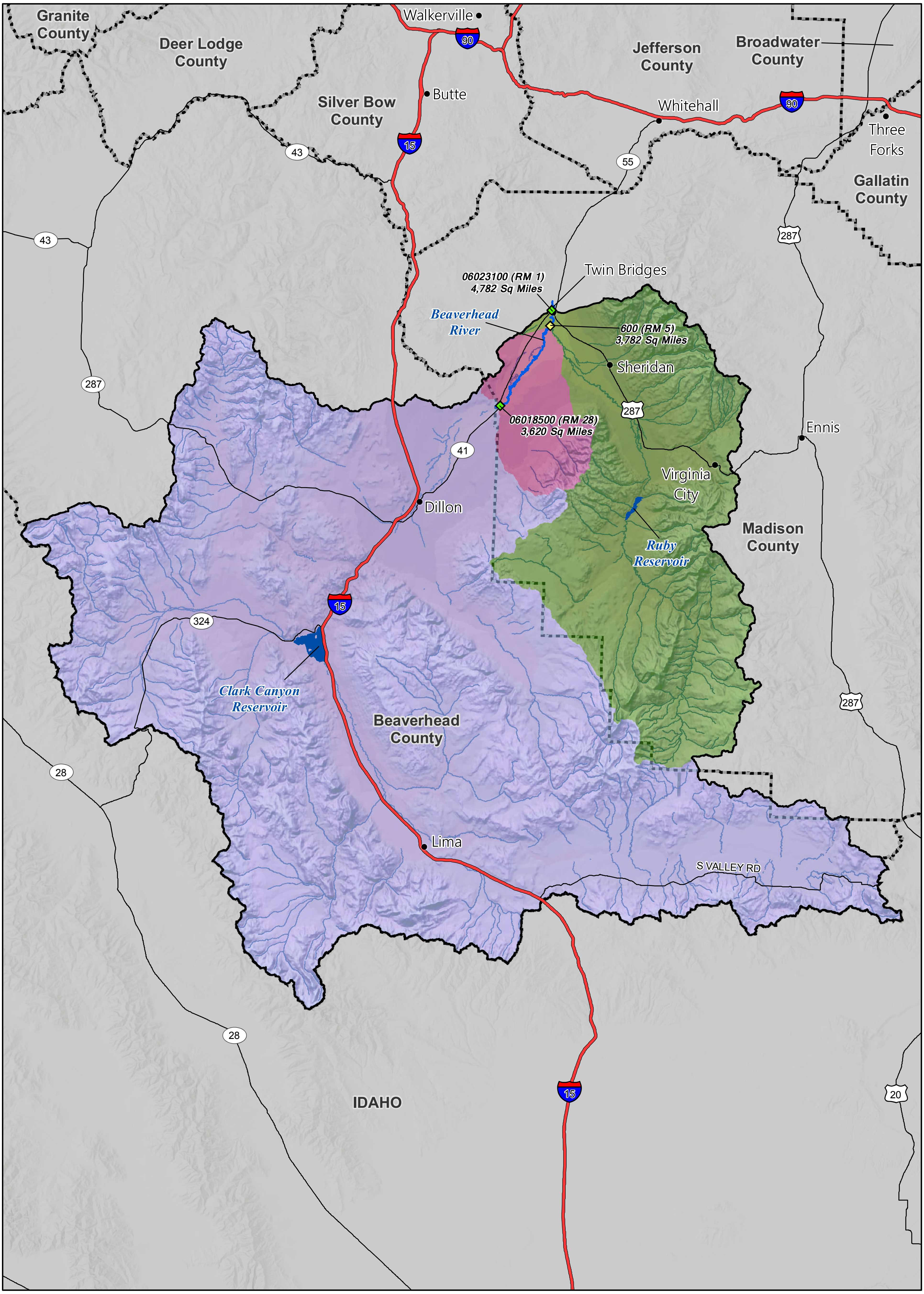
JEFFERSON RIVER WATERSHED

FIGURE 2

Map Date: 5/23/2018



LEGEND

Flow Change Basin

- 06018500
- 600 (RM5)
- 06023100

- Flow Change Location
- USGS Gage
- Study Reach
- Towns
- Counties
- Interstate
- Highway

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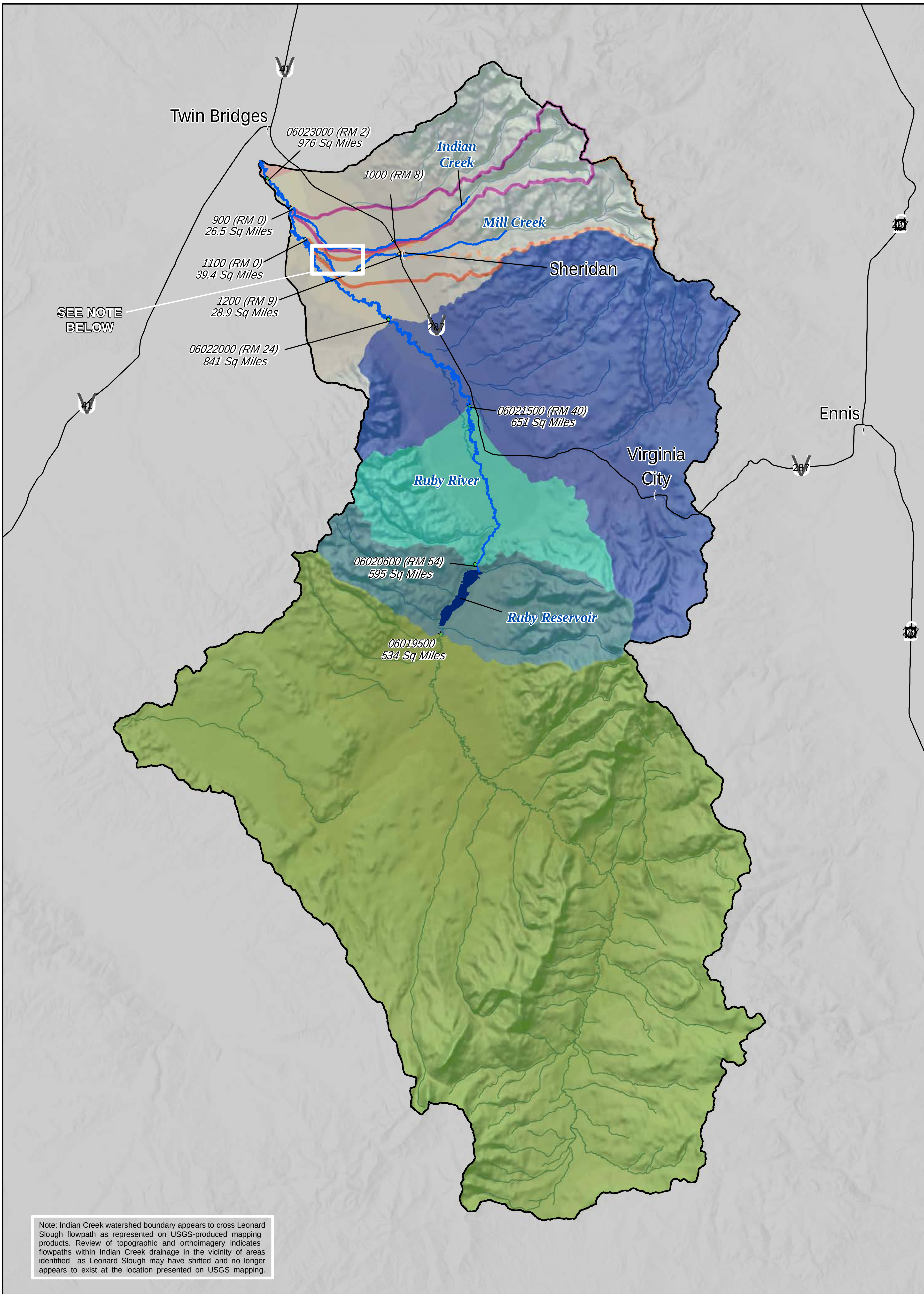
DATA FRAME PROPERTIES:
Coordinate System: NAD 1983 StatePlane Montana FIPS 2500 Feet Intl
Projection: Lambert Conformal Conic
Datum: North American 1983
Units: Foot

0 5 10 20 Miles

BEAVERHEAD RIVER WATERSHED

FIGURE 3

Map Date: 5/23/2018



LEGEND

Flow Change Basin

- 1000 (RM 8)
- 900 (RM 0)
- 1200 (RM 9)
- 1100 (RM 0)
- 06019500
- 06020600
- 06021500
- 06022000
- 06023000
- Flow Change Location
- USGS Gage
- Study Reach
- Towns
- Counties
- Interstate
- Highway

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DATA FRAME PROPERTIES:
Coordinate System: NAD 1983 StatePlane Montana FIPS 2500 Feet Intl
Projection: Lambert Conformal Conic
Datum: North American 1983
Units: Foot

0 2 4 8 Miles

RUBY RIVER WATERSHED

FIGURE 4

Map Date: 7/5/2018

Figure 5: USGS 06036650 Jefferson River near Three Forks MT.

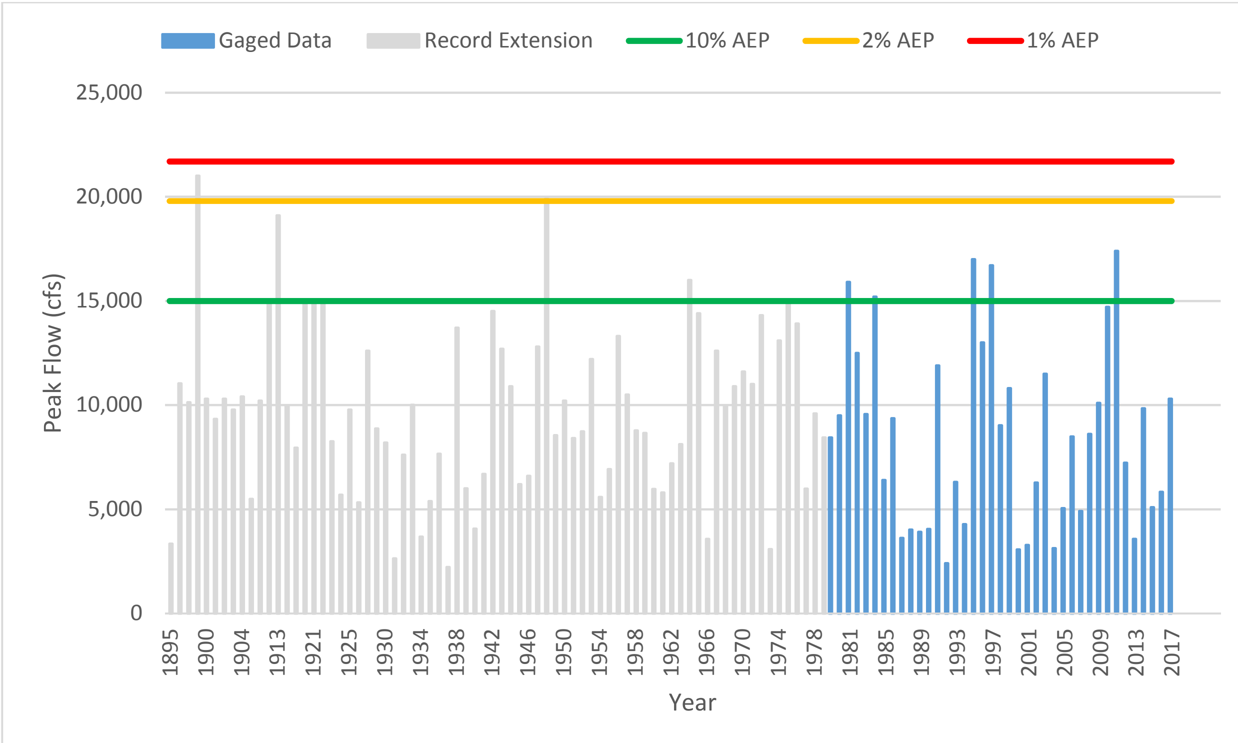


Figure 6: USGS 06026500 Jefferson River near Twin Bridges MT.

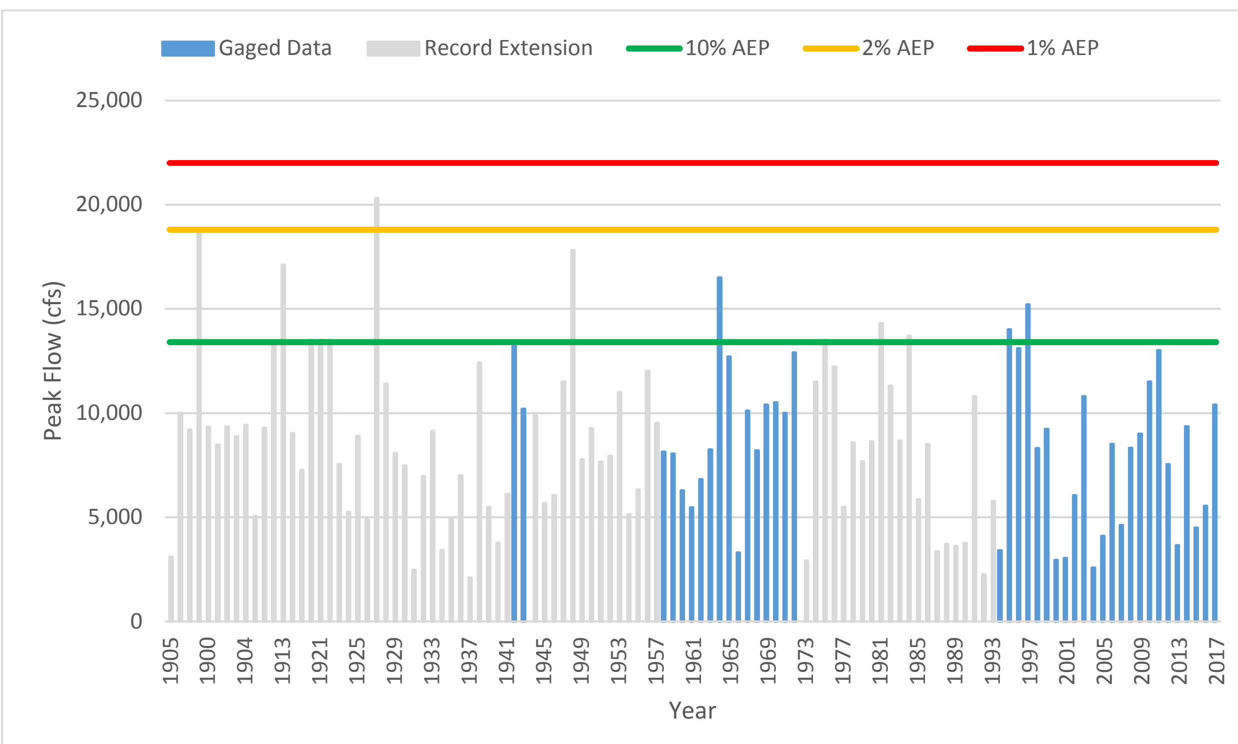


Figure 7: USGS 06018500 Beaverhead River near Twin Bridges MT. (Note – No record extension applied to this gage and period of record for analysis begins in 1965, following closure of Clark Canyon Dam).

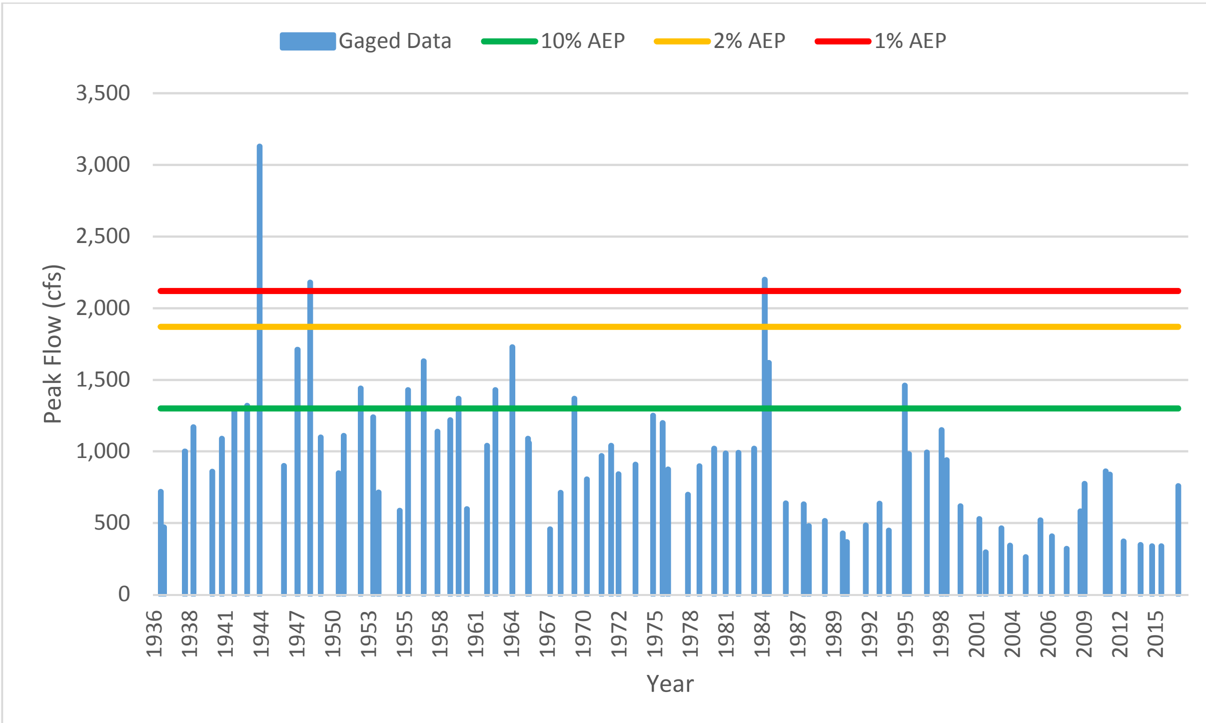


Figure 8: USGS 06023000 Ruby River near Twin Bridges MT.

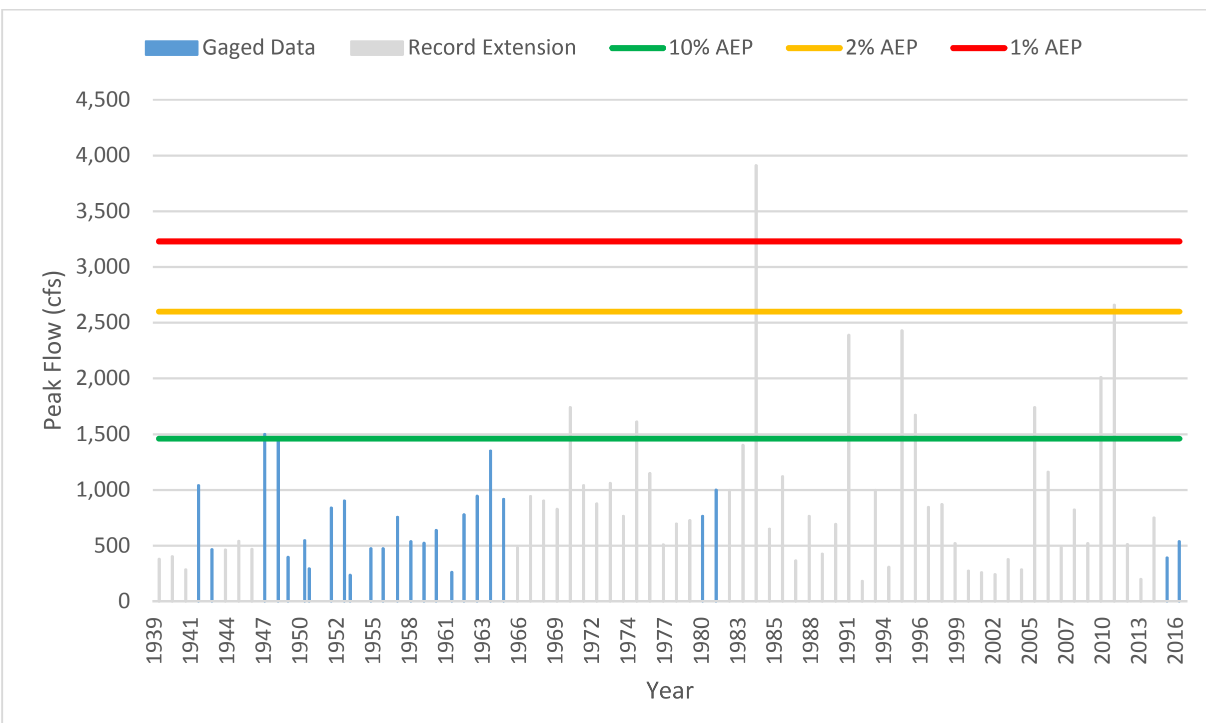


Figure 9: USGS 06022000 Ruby River bl Ramshorn Cr nr Alder MT.

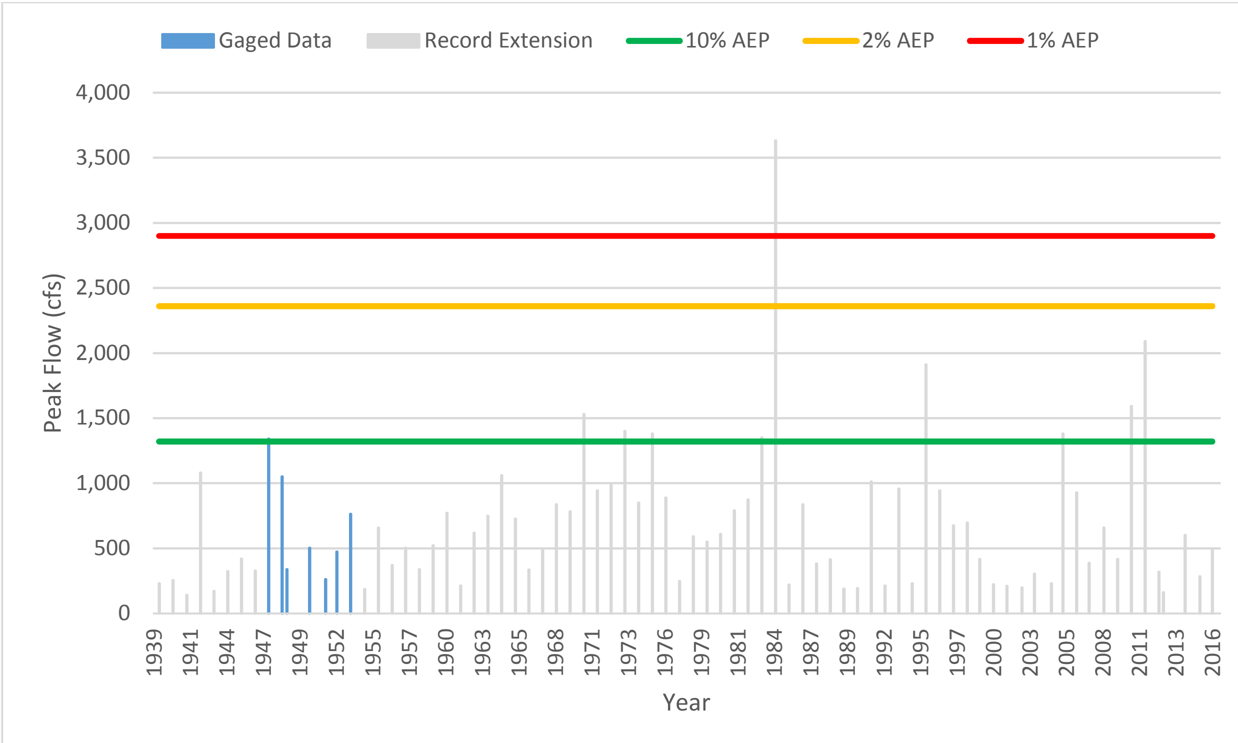


Figure 10: USGS 06021500 Ruby River at Laurin MT.

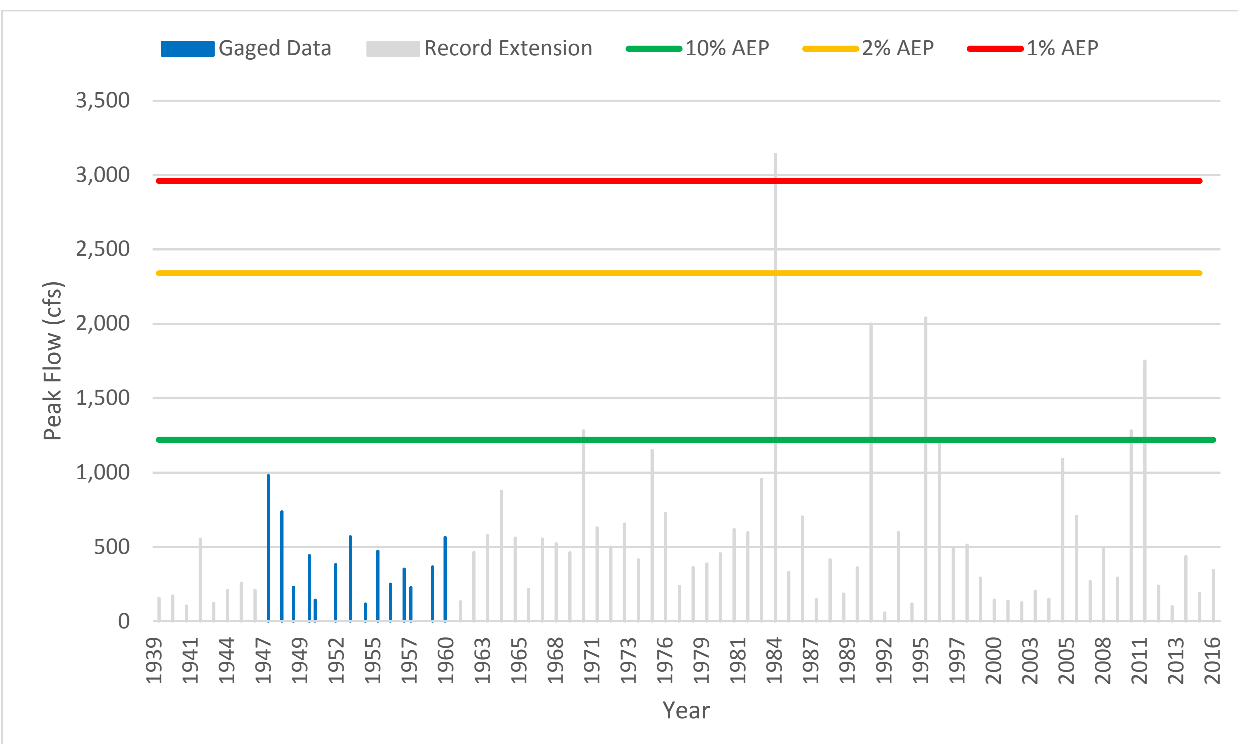


Figure 11: USGS 06020600 Ruby River below reservoir near Alder, MT.

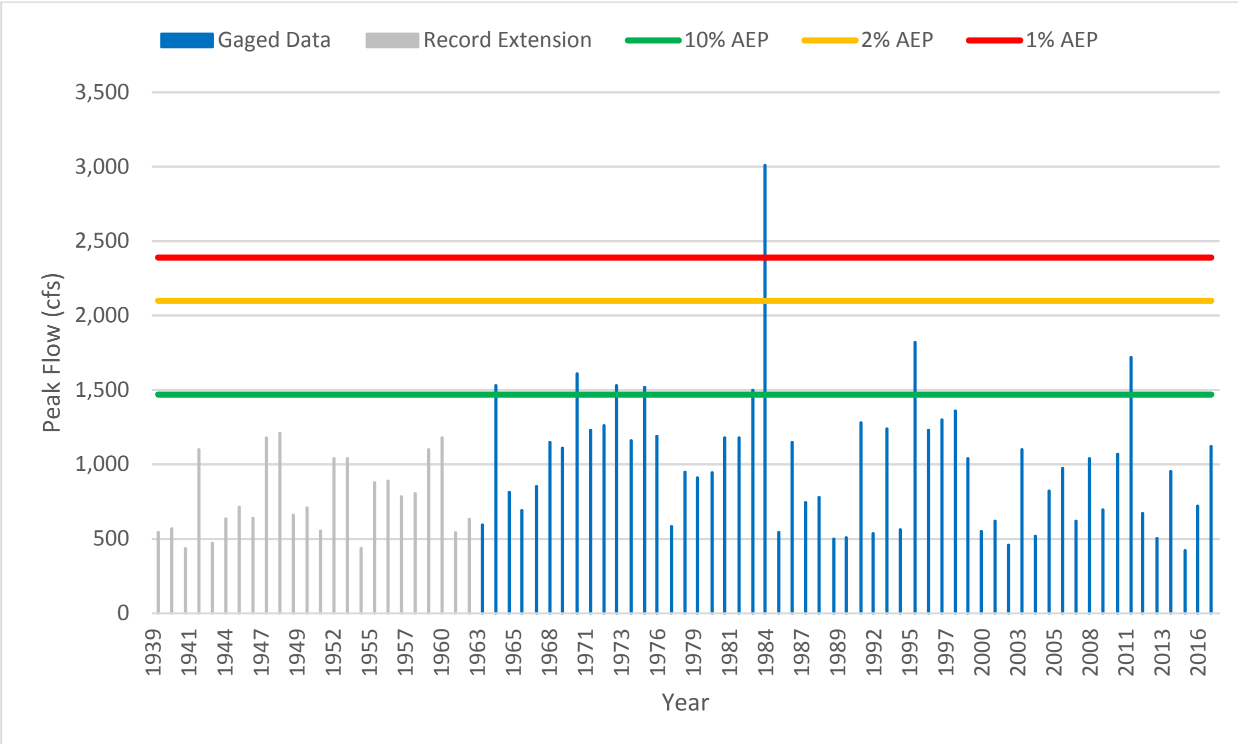
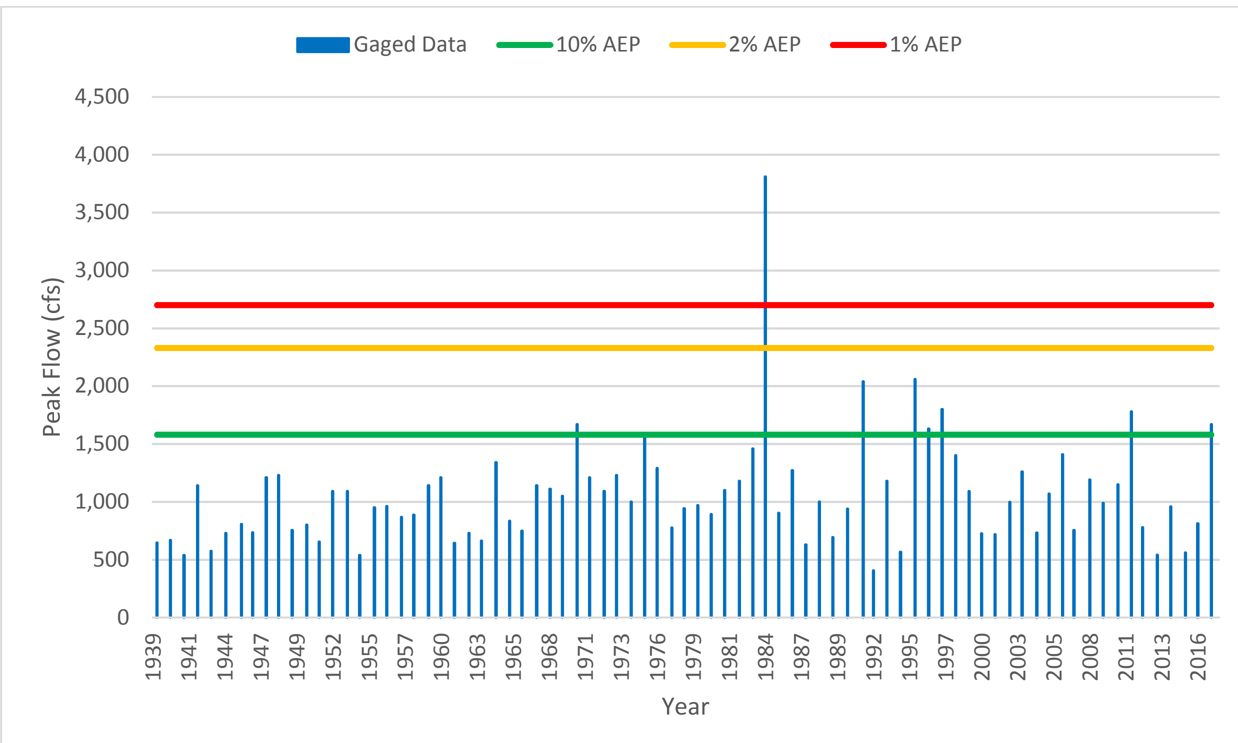


Figure 12: USGS 06019500 Ruby River above reservoir near Alder, MT. (Note – record extension methods not utilized at this site)



3. Previous Studies

A limited number of previous studies are available for the Jefferson River and tributaries within the study area. Various sources of information are tied to previous FEMA flood insurance studies, other flood hazard studies, and data compiled by the USGS for stream gages within the watershed. A summary of the existing studies and documents are provided in the following sections.

3.1. Gallatin County, Montana and Incorporated Areas Flood Insurance Study

A Flood Insurance Study (FIS) for Gallatin County, Montana and Incorporated Areas was published effective by FEMA on September 2, 2011 (FEMA 2011). An updated version of this FIS was issued preliminary on February 16, 2018 for studies outside of the Jefferson River watershed. Both versions describe the flooding sources and hydrologic analyses for the City of Three Forks and the portion of the Jefferson River watershed within Gallatin County. The FIS describes the 1948 flood event as the most recent major flood on the Jefferson River (19,900 cfs at the City of Three Forks, approximately 25-year event) and notes that flows overtopped US Highway 10 west of the overpass at the Chicago, Milwaukee, St. Paul and Pacific Railroad southwest of Three Forks, with some flood flows in the western areas of Three Forks. The FIS references previous hydrologic analyses performed for the City of Three Forks, including an NRCS study from 1979 and a re-study completed in 2004 by Van Mullem Engineering.

The 2004 Van Mullem Engineering hydrologic analysis was performed for a Letter of Map Revision (LOMR, No. 05-08-A579P) in the City of Three Forks, issued by FEMA June 29, 2006. Van Mullem performed a peak discharge frequency analysis following USGS Bulletin 17B methods for nearby USGS gages (Jefferson River at Sappington (06034500) and Jefferson River at Three Forks (06036650)) using Log-Pearson Type III distribution. Van Mullem estimated a 1% Annual Exceedance Probability (AEP) discharge of 23,100 cfs (Van Mullem 2003), a reduction of 4,500 cfs from the NRCS 1979 estimated discharge of 27,600 cfs.

Peak discharge relationships for the Jefferson River near the Town of Three Forks were based on regional regression equations developed using peak discharge data for selected frequencies and drainage area data from 19 selected USGS stream gages in the surrounding area. Three gages on mainstem Jefferson River were included in the analysis (060265 Jefferson River near Twin Bridges, 060272 Jefferson River near Silverstar, and 060345 Jefferson River near Sappington). The source data for the gage analyses are USGS Compilation of Records of Surface Waters of the US through September 30, 1950; 1950 – 1960 in Missouri River Basin above Sioux City, IA; and 1961 – 1975 Water Resources Data for Montana. The FIS reports the regression equations gave values higher than those that would be determined from Bulletin 17A analysis of gages at Twin Bridges and near Three Forks, but lower than Bulletin 17A analysis of Silverstar gage. "To balance out inconsistencies", the regression equation results were used. The results of the hydrologic analysis reported in the FIS are provided in Table 3. The FIS notes a US Army Corps of Engineers (USACE) report for a proposed levee to protect Three Forks from Jefferson River flooding. The USACE report provides information on the

1948 flood, and reports higher peak discharge values than the 2011 FIS due to different computational methods (USACE 1970).

3.2. Big Pipestone Creek

The Soil Conservation Service (now NRCS) performed a flood study on Big Pipestone Creek - a tributary to the Jefferson River near Whitehall, MT (SCS, 1984). The Big Pipestone Creek study covered the lower 6.5 miles of the creek, with downstream limits at the confluence with the Jefferson Slough, a secondary channel of the Jefferson River. This reach flows along the southern edge of Whitehall and the upstream study limit is about 4 miles west of Whitehall. The purpose of the flood study was to determine flood characteristics for flood events over a range of recurrence intervals (0.2%, 1%, 2%, and 10% AEP), communicate the flood risk by developing flood hazard maps for the 0.2% and 1% AEP floods, and identify actions that the community could take to mitigate flood risk. The study identified a 1981 flood event as being one of the larger flood events on Big Pipestone Creek at the date of the study (1984). The estimated recurrence interval for the 1981 flood event was in the 5% to 10% AEP range, and was driven by a significant precipitation event rather than snowmelt, which is the more common flooding process in the watershed. Because of a lack of gage data, the hydrologic data used in the analysis was developed using the SCS hydrologic computer program TR20 “Computer Program for Project Formulation Hydrology” computer model, which applies unit hydrograph – runoff curve number methodologies. The results were compared with regression equations developed from gaged data at 15 sites in southwestern Montana. The hydraulic analysis was performed using SCS WSP2 computer program. Flood hazard maps were prepared to indicate flood extents for the 1% and 0.2% AEP floods. A floodway analysis was performed in this reach and the floodway is delineated on the Flood Hazard Maps. The water surface elevations are included at the cross section locations indicated on Flood Hazard Boundary maps, along with the profile plots for the reach.

4. Hydrologic Analyses and Results

Hydrologic analyses performed in this study identify the peak flow discharge estimates for flood events corresponding to the 10%, 4%, 2%, 1%, 0.2%, and 1% ’plus’ AEP at specific locations within the Jefferson River watershed. The locations for these calculations define flow change locations throughout the watershed and generally correspond to stream gage locations, the confluence with significant tributaries in the watershed, local communities, and other locations where the flood frequency characteristics are likely to change (e.g. at dams and reservoirs). The analyses performed to determine peak flow characteristics at these locations include USGS stream gage analysis and flow determination using methods at ungaged stream locations.

As indicated in Figure 1, the Jefferson River watershed within this study area is composed of the Jefferson River sub-watershed, Beaverhead River watershed, and Ruby River watershed. Additionally, South Boulder River is a tributary to the Jefferson River and represents a sub-basin with the Jefferson River watershed. Similarly, Indian Creek and Mill Creek are tributaries to the Ruby River and represent sub-basins to the Ruby River. USGS operates a number of stream gages on the Jefferson, Beaverhead, and Ruby Rivers, and the stream gage analyses were performed on select gages on these rivers. Given the large distances between stream gage locations on these rivers, intermediate flow change locations have been identified that recognize the contribution of other tributaries and increases in drainage area along these rivers between gaged sites. Peak flow estimates at these intermediate flow change locations were performed using flow determination methods at ungaged stream locations. South Boulder River, Indian Creek, and Mill Creek are ungaged tributaries and peak flow estimates for these tributaries has been performed using methods for ungaged sites.

Seven flow change locations have been identified on the Jefferson River (Figure 2). Two of these are at USGS gaging sites (06026500 Jefferson River near Twin Bridges and 06026650 Jefferson River near Three Forks). The remaining five flow change locations on the Jefferson River are associated with tributaries or significant changes in the contributing drainage area. Three flow change locations have been identified along the Beaverhead River (Figure 3). Two of these flow change locations are at stream gage sites (06023100 Beaverhead River at Twin Bridges and 06018500 Beaverhead River near Twin Bridges), while the remaining location is just upstream of the confluence with the Ruby River. Along the Ruby River, eight flow change locations have been identified (Figure 4), with five of these located at stream gage sites (06023000 Ruby River near Twin Bridges, 06022000 Ruby River below Ramshorn Creek near Sheridan, 06021500 Ruby River at Laurin, 06020600 Ruby River below reservoir, near Alder, and 06019500 Ruby River above reservoir, near Alder), and the remaining three at tributaries or significant changes in the contributing drainage area.

4.1. USGS Stream Gage Analysis

Historically, the USGS has operated six stream gages on the Jefferson River within the study area. Of these six gages, three gages are inactive and one gage began recording flow data in 2006. The inactive gages have a relatively short flow record or do not contain recent flow data that would provide relevant information for this study. The remaining two gages are used for peak flow estimates in this study and have record extension statistical methods (using Maintenance of Variance Extension Type III (MOVE.3)) applied to the flow data to significantly extend the flow record. The MOVE.3 analysis was able to extend the flow record from 65 peak flow events to 111 peak flow events at one site, and 80 peak flow events to 111 peak flow events at the other site. The USGS data release (Sando and McCarthy 2018) for the Jefferson River Watershed gages provides a summary of the analyses performed at the gages. The data release provides results of the at-station (using only peak flow data at the gage) analyses, and results of the sites where record extension methods were applied. Where utilized, the results of the record extension methodology are reported in this document and form the basis of flow recommendations. The record extension results are deemed more reliable based on the significantly longer flow record incorporated in the analysis and robust statistical methodologies utilized in applying the record extension.

Along the Beaverhead River within the study area, the USGS has operated two stream gages, both of which are currently active. However, one stream gage began recording flow data in 2008 and only records flow data July through September and consequently is not used in this study. The other stream gage is used in this analysis and has 52 peak flow records for the analysis.

The USGS has historically operated nine stream gages on the Ruby River. Of these nine gages, five gages are used in this analysis while the other four gages are not used. All four of the gages excluded from the analysis are inactive, as are two of the five gages used in the analysis. However, the flow record of the two inactive gages used in the analysis are able to be extended significantly using MOVE.3 statistical methods described in Methods for Peak-Flow Frequency Analysis and Reporting for Streamgages in or near Montana Based on Data through Water Year 2015 (Sando and McCarthy 2018). The MOVE.3 analysis extended the peak flow record to 78 events at all five gages used in the analysis, up from as few as 14 peak flow events at one of the sites.

Table 2 lists USGS stream gages and gage information for the Jefferson, Beaverhead, Ruby Rivers gages that are used in this study.

Under an agreement with Montana DNRC, the USGS performed a peak-flow frequency analysis for selected gages in the Jefferson, Beaverhead, and Ruby Rivers. This analysis was specific to the study area included in this report and is documented in a standalone USGS data release (McCarthy, et al. 2018). With the exception of the Beaverhead River gage station and the Ruby River gage station above the Ruby Reservoir, flood frequency estimates at the remaining stations (those with short records, affected by flow regulation, or with large drainage areas (typically larger than 2,750 mi^2)) were analyzed using the mixed-station record extension methodology Mixed-Station Maintenance of Variance Type 3 (MOVE.3). The MOVE.3 analysis results are utilized for the recommended flow values because these results are deemed more reliable given the extended period of record applied to the gaging stations. Details of how USGS applied the MOVE.3 analysis to synthesize peak flow data are provided in detail in Chapter D of Montana StreamStats (Sando, et al. 2018a) and summarized below. The MOVE.3 methodology is based on correlation of concurrent peak-flow records for the target station (station with incomplete flow records) with one or more index stations (stations with peak flow records for one or more of the missing years of the target station). The procedure evaluates the strength of the relationship between peak discharges at target and index stations for the same year and adjusts the peaks for the index stations to fit the characteristics of the target station for the missing year data. Documentation regarding the application of the mixed-station MOVE.3 procedure is provided in the USGS data release (McCarthy, et al. 2018). Analyses for the Beaverhead River and Ruby River (above Ruby Reservoir) stream gages were performed using at-station peak flow data following procedures described Bulletin 17C “Guidelines for Determining Flood Flow Frequency” (England et al., 2018).

Table 2: USGS stream gages and gage information used in this study.

Gage Station Number	Station Name	Drainage Area (mi^2)	Peak-flow analysis type	Water Years of Peak Flows Used in Analysis[1]	Number of Peak Flows Used in Analysis[1]	River Station
Jefferson River						
06036650	Jefferson River near Three Forks, Montana	9,558	MOVE.3	1895, 1897–1905, 1911–16, 1921–26, 1928–2016 (1895, 1897–1905, 1939–69, 1975, 1979–2016)	111 (80)	7
06026500	Jefferson River near Twin Bridges, Montana	7,616	MOVE.3	1895, 1897–1905, 1911–16, 1921–26, 1928–2016 (1911–16, 1921–39, 1942–43, 1958–72, 1994–2016)	111 (65)	71
Beaverhead River						
06018500	Beaverhead River near Twin Bridges, Montana	3,618	At-site	1965–2016	52	28
Ruby River						
06023000	Ruby River near Twin Bridges, Montana	970	MOVE.3	1939–2016 (1942–43, 1947–65, 1980–81, 2015–16)	78 (25)	2
06022000	Ruby River below Ramshorn Creek, near Sheridan, Montana	839	MOVE.3	1939–2016 (1947–53, 1997–2011, 2013–16)	78 (26)	24
06021500	Ruby River at Laurin, Montana	643	MOVE.3	1939–2016 (1947–60)	78 (14)	40
06020600	Ruby River below reservoir, near Alder, Montana	595	MOVE.3	1939–2016 (1963–2016)	78 (54)	54
06019500	Ruby River above reservoir, near Alder, Montana	534	At-site	1939–2016	78	NA

[1] Numbers in parenthesis represent peak flow events and corresponding years without applying MOVE.3 analysis

Figures 13 through 15 provide the calculate AEP flow values as a function of basin area for the Jefferson River, Beaverhead River, and Ruby River, respectively. There are only two gaging stations used in this analysis on the Jefferson River (060265000 near Twin Bridges and 06036650 at Three Forks). Although there are only two gages, the peak flows indicate the expected response of increasing peak flows for the gage further down the watershed.

While there are two gaging station on the Beaverhead River within this study area, one of the gages (06023100 Beaverhead River at Twin Bridges) is seasonally operated by USGS during July through

September and is not included in this study. A recent hydrologic study on the Beaverhead (Pioneer Technical Services, 2017) shows that the downstream response of peak flows on the Beaverhead do not follow the expected response of increasing flows in the downstream direction (Figure 14). Figure 14 indicates that below Clark Canyon Dam, the peak flows at USGS gage at Barretts (06016000) are higher than the three gages located downstream (06017000 at Dillon; 06018000 near Dillon; 06018500 near Twin Bridges). Pioneer attributes this response to the high capacity of the Beaverhead River floodplain in the area to attenuate peak flows via overbank storage and several flow diversions located in the Beaverhead River valley. The lower gage in the Pioneer study overlaps with the Jefferson River at the USGS gage near Twin Bridges (06018500). This gage is the lowermost gage analyzed for the Beaverhead River watershed study and is the only Beaverhead River gage analyzed in this Jefferson River watershed study. Although the peak flows at the 06018500 gaging station are lower than the peak flow values at Barretts, the peak flows at this gage are higher than the peak flows at the next upstream gage near Dillon (06018000), suggesting a reverse in the downward trend in peak flows with increasing watershed area.

There is a relatively high density of gages on the Ruby River analyzed by USGS for this study. The peak flow data presented in Figure 15 and Table 3 for the gaging stations below the Ruby Reservoir show a general increasing trend in peak flow values for gage locations in the downstream direction. Additionally, the peak flow gage analysis suggests that Ruby Reservoir provides peak flow attenuation, as the peak flow values above Ruby Reservoir (06019500) are substantially larger than the peak flow values immediately below Ruby Reservoir (06020600) and even the next gage station downstream at Laurin (06021500) (Figure 15).

Figure 13: Annual Exceedance Probabilities for Jefferson River flow gages evaluated by this study.

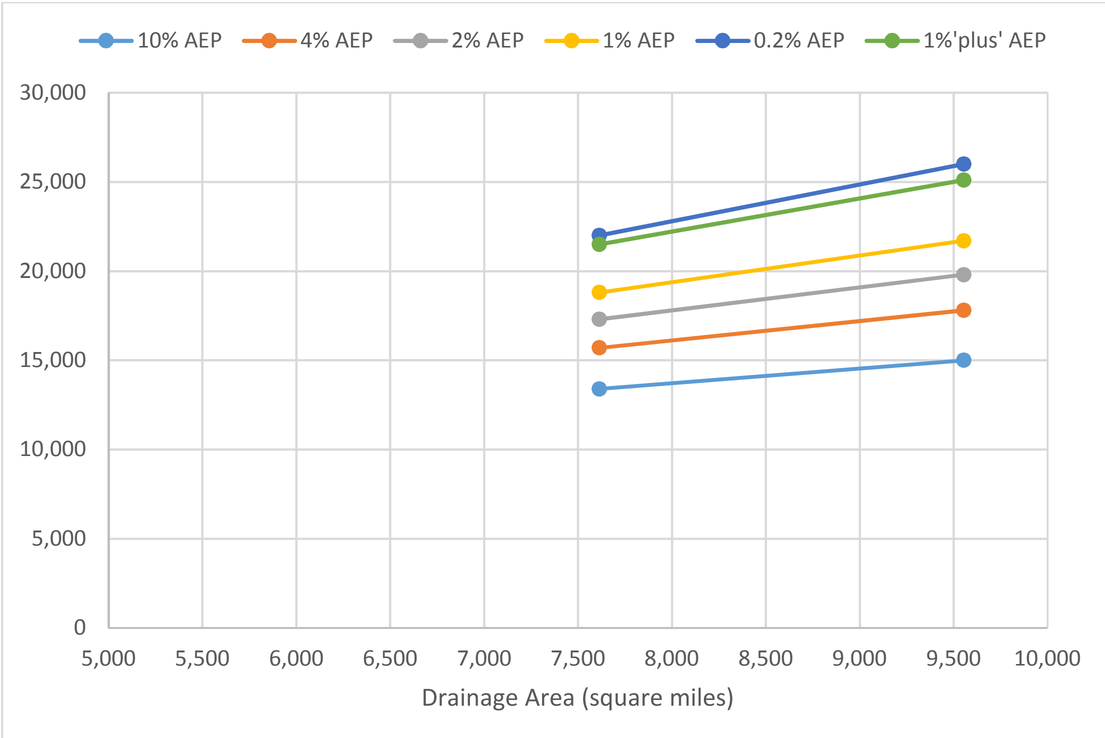


Figure 14: Annual Exceedance Probabilities for Beaverhead River flow gages evaluated by this study. (Note - data for gages above this study from Pioneer, 2017)

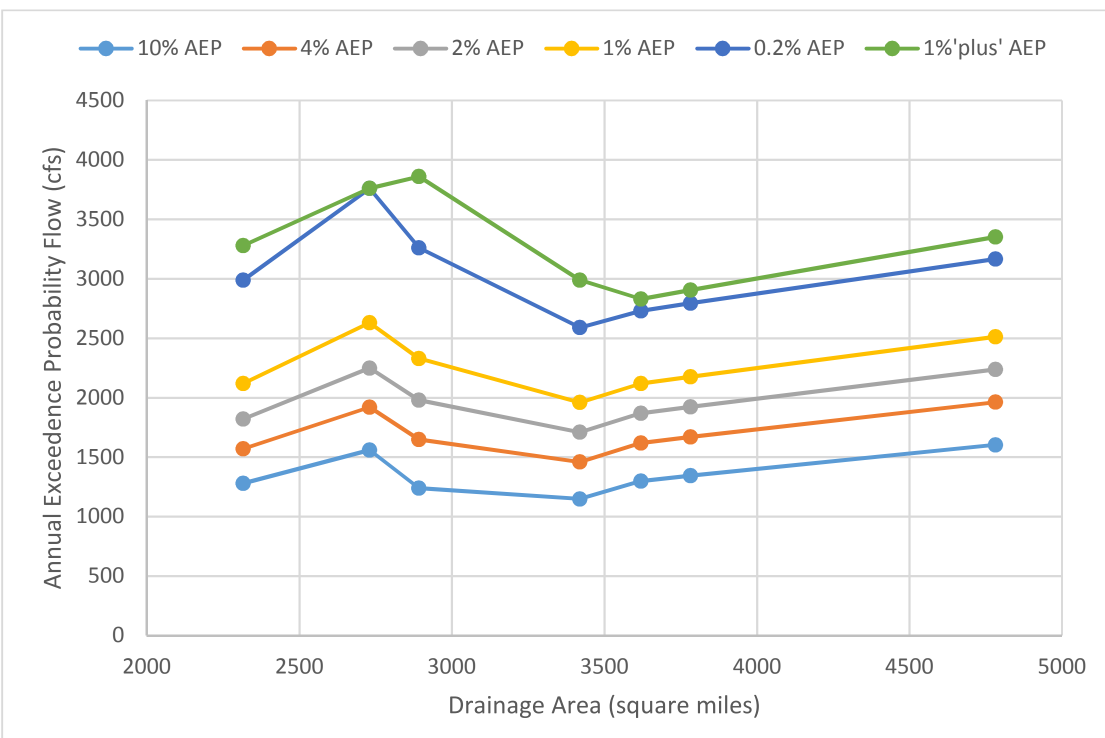


Figure 15: Annual Exceedance Probabilities for Ruby River flow gages evaluated by this study.

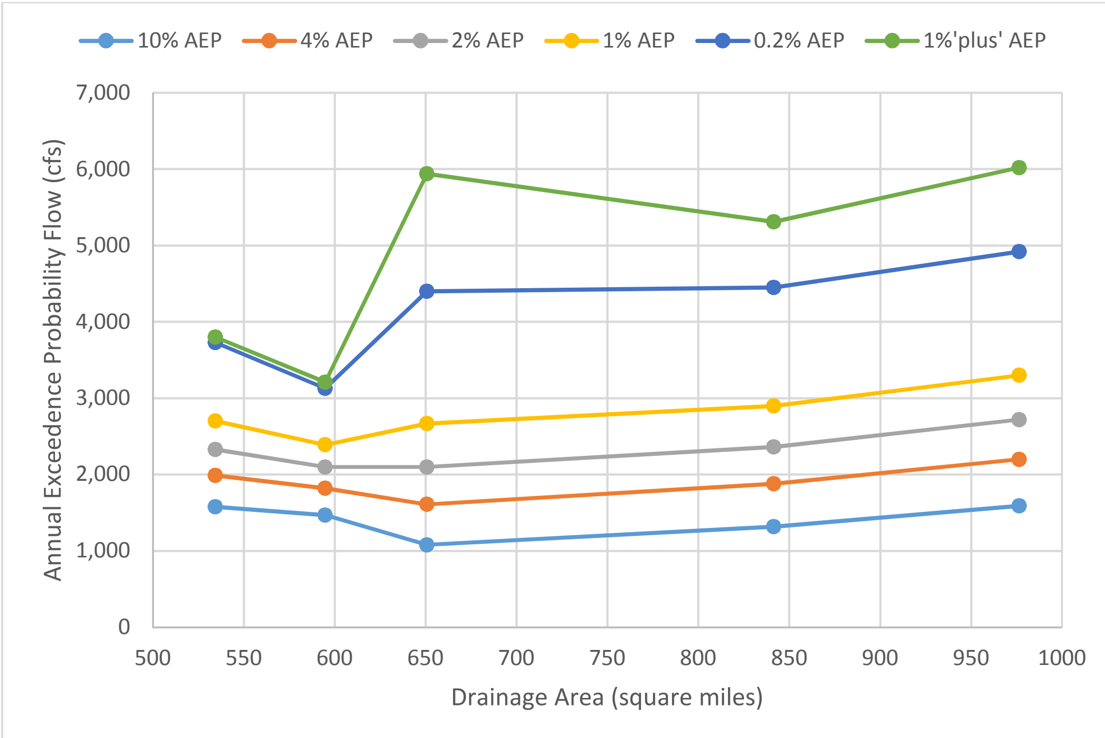


Table 3: Peak discharge comparison 2016 data analysis compared to 2011 data analysis. (FIS data included in parentheses for gage 06036650).

Station Number	Station Name	Peak Discharge (cfs) for Annual Exceedance Probability (%) Flows									
		10%		4%		2%		1%		0.2%	
		2011	2016	2011	2016	2011	2016	2011	2016	2011	2016
Jefferson River											
06036650	Jefferson River near Three Forks, MT	15,100	15,000 (18,300)	17,300	17,800 (*1)	18,800	19,800 (25,000)	20,200	21,700 (27,600)	23,200	26,000 (34,000)
06026500	Jefferson River near Twin Bridges, MT	13,000	13,400	14,600	15,700	15,700	17,300	16,800	18,800	18,900	22,000
Beaverhead River											
06018500	Beaverhead River near Twin Bridges, MT	1,330	1,300	1,630	1,620	1,860	1,870	2,080	2,120	2,610	2,730
Ruby River											
06023000	Ruby River near Twin Bridges, MT	1,460	1,590	2,060	2,200	2,600	2,720	3,230	3,300	5,100	4,920
06022000	Ruby River below Ramshorn Creek, near Sheridan, MT		1,320		1,880		2,360		2,900		4,450
06021500	Ruby River at Laurin, MT	1,220	1,080	1,800	1,610	2,340	2,100	2,960	2,670	4,840	4,400
06021000	Ruby River near Alder, MT	1,460		1,990		2,430		2,900		4,140	
06020600	Ruby River below reservoir, near Alder, MT	1,480	1,470	1,840	1,820	2,120	2,100	2,430	2,390	3,230	3,130
06019500	Ruby River above reservoir, near Alder, MT	1,620	1,580	1,990	1,990	2,290	2,330	2,600	2,700	3,430	3,730

*1 FIS data not available

4.1.1. 1% Plus Peak Flow Estimates

As previously discussed, FEMA flood risk products employ a method for determining peak discharge estimates for a standard error of prediction above the 1% AEP, known as the 1% Plus discharge. The purpose of the 1% plus analysis is to highlight uncertainty within the hydrologic model and potential underestimations in the resulting modeled flood elevations by using the upper confidence limits (84%) to compute higher flood discharge (FEMA 2012). Baker staff reviewed supplemental information provided by USGS (Sando, pers. comm. 2018) and incorporated the 1% plus results for the Jefferson River, Beaverhead River, and Ruby River stream gages listed in Table 4. For ungaged locations where regional regression equations were used, the 1% plus peak flow estimates were performed by applying the standard error of prediction (SEP) to the calculated 1% AEP peak flow value and adding it to the calculated 1% AEP peak flow value. USGS Methods for Estimating Peak-flow Frequencies at Ungaged Sites in Montana Based on Data Through Water Year 2011, Chapter F (Sando et al. 2018b) reports the SEP for the 1% AEP regression equation for the Southwest region is 73.8%. Table 4 lists the 1% plus AEP peak flow values calculated for the stream gages utilized in this study. Supporting documentation from the USGS flood-flow frequency analyses and 1% Plus calculations are included in Appendix B.

4.2. Flow Change Node Locations

The hydrologic data prepared in this report is intended to describe the general hydrologic conditions within the Jefferson River watershed areas of interest. One of the uses of the data from this study are to describe flood risk for the communities within the Jefferson River watershed, which involves developing hydraulic models based on these hydrologic data and stream channel and floodplain characteristics to develop predicted water surface elevations through the study area. These water surface elevations are then applied to topographic data to develop floodplain boundaries, inundation maps, depth grids, and other useful mapping products. However, over the approximately 75 miles of the Jefferson River, peak flow data have only been determined at two USGS gaging stations, and those estimated discharges differ by about 3,000 cfs. A similar situation exists on the Beaverhead River in this study area, however for the case of the Beaverhead River, there are two ungaged locations identified as requiring flow estimates, and both are located downstream of the only gaged site used for the analysis (Beaverhead River near Twin Bridges USGS 06018500). As a result, intermediate flow change locations are required at locations along the Jefferson and Beaverhead Rivers to better describe the flow conditions along these rivers at locations without stream gages. Table 4 lists the flow change locations along each of the study reaches and indicates whether the location is a stream gage location or is included as an intermediate flow change location. By definition, the intermediate flow change locations are ungaged (or only gaged during part of the year) sites, and methods described in the “Gage Transfer to Ungaged Sites” (Sando et al. 2018b) were used to estimate peak-flow frequencies at these locations.

Table 4: Gage and flow node locations and recommended AEP flows.

Node ID	Station / Node Number	Station/Node Name	Drainage Area[1] (square miles)	Peak Discharge (cfs) for Annual Exceedance Probability (%) Flows 10%	4%	2%	1%	0.2%	1% Plus
Jefferson River									
8	100	Jefferson River Confluence with Madison	9,629	15,088	17,896	19,900	21,803	26,108	25,219
9	06036650	Jefferson River near Three Forks, MT	9,554	15,000	17,800	19,800	21,700	26,000	25,100
10	200	Jefferson River above Willow Cr	9,300	14,801	17,537	19,486	21,334	25,490	24,643
11	300	Jefferson River above South Boulder River	8,335	14,016	16,505	18,256	19,906	23,515	22,868
1	400	Jefferson River above Fish Creek	7,832	13,590	15,948	17,594	19,139	22,463	21,919
3	06026500	Jefferson River near Twin Bridges, MT	7,614	13,400	15,700	17,300	18,800	22,000	21,500
Beaverhead River									
4	06023100[3]	Beaverhead River at Twin Bridges, MT	4,782	2,350	3.190	3,910	4,720	7,030	6,760
5	600	Beaverhead River above Confluence with Ruby River	3,782	1,344	1,670	1,924	2,177	2,795	2,907
7	06018500	Beaverhead River near Twin Bridges	3,620	1,300	1,620	1,870	2,120	2,730	2,830
	06018000[2]	Beaverhead River near Dillon	3,419	1,150	1,460	1,710	1,960	2,590	2,990
	06017000[2]	Beaverhead River at Dillon	2,892	1,240	1,650	1,980	2,330	3,260	3,860
	06016000[2]	Beaverhead River at Barretts	2,730	1,560	1,920	2,250	2,630	3,760	3,760
	06015400[2]	Beaverhead River near Grant	2,316	1,280	1,570	1,820	2,120	2,990	3,280
Ruby River									
14	06023000	Ruby River near Twin Bridges, MT	977	1,590	2,200	2,720	3,300	4,920	6,020
17	06022000	Ruby River below Ramshorn Creek near Sheridan, MT	841	1,320	1,880	2,360	2,900	4,450	5,310

Node ID	Station / Node Number	Station/Node Name	Drainage Area[1] (square miles)	Peak Discharge (cfs) for Annual Exceedance Probability (%) Flows					
				10%	4%	2%	1%	0.2%	1% Plus
18	06021500	Ruby River at Laurin, MT	651	1,080	1,610	2,100	2,670	4,400	5,940
19	06020600	Ruby River below Ruby Reservoir near Alder, MT	595	1,470	1,820	2,100	2,390	3,130	3,210
20	06019500	Ruby River above Ruby Reservoir near Alder, MT	534	1,580	1,990	2,330	2,700	3,730	3,800
Indian Creek									
21	900	Confluence with Wisconsin Cr near Ruby River	27	213	311	392	486	738	845
22	1000	Indian Creek at Sheridan, MT	14	119	169	210	257	378	446
Mill Creek									
23	1100	Mill Creek at Confluence with Ruby River	39	279	390	479	580	840	1,008
24	1200	Mill Creek at Sheridan, MT	30	213	295	360	433	620	753
South Boulder River									
12	700	South Boulder River at Confluence with Jefferson River	80	493	670	808	962	1,354	1,672
25	800	South Boulder River at Canyon	63	390	524	627	741	1,028	1,288

[1] Drainage area based on delineation of watershed using StreamStats with manual correction if necessary and may differ slightly from drainage area reported by USGS for gage location

[2] Beaverhead River streamgage data included for reference and completed under 2017 analysis (Pioneer 2017)

[3] Beaverhead River at Twin Bridges (USGS 06021300) stream gage is only operated July – September. Flows calculated using alternate methods described in .

4.3. Gage Transfer to Ungaged Sites

To provide a better representation of the flow distribution through the Jefferson River study corridor, intermediate flow change locations have been identified to represent the influences of tributaries and other watershed features on the flow distribution along the Jefferson River. For the Jefferson River, these flow changes correspond to input from the Willow Creek watershed and the Boulder River and South Boulder River watersheds. An additional flow change location was located between the

Jefferson River gage station near Twin Bridges (060265000) and the South Boulder River watershed to account for watershed processes occurring along this long stretch of the Jefferson River. Similarly, a significant portion of the Jefferson River watershed lies below the USGS gaging station at Three Forks (06036650) down to the confluence with the Madison River, requiring an analysis to describe the hydrologic characteristics in this area. As described above, the lone Beaverhead River gaging station used in this study is located upstream of two identified flow change locations.

Montana StreamStats Chapter F (Sando et al. 2018b) provides gage transfer methodologies to estimate peak flow characteristics at ungaged locations that are either a) near a stream gage station (Equation 1); or b) between stream gaging stations (Equation 2).

4.3.1. Estimating Peak-Flow Frequencies at an Ungaged Site on a Gaged Stream

USGS SIR 20155019 Chapter F (Sando et al. 2018b) provides the methodology for estimating the peak-flow frequency when an ungaged site is close to a gaging station on the same river. The drainage-area ratio adjustment methodology is provided in Chapter F and is provided below. This method was utilized to estimate the peak-flow frequencies on the Jefferson River below the USGS gaging station at Three Forks (06036650) and for one ungaged site on the Beaverhead River at the confluence of the Ruby River and at Twin Bridges below the USGS gaging station near Twin Bridges (06018500). As noted in SIR 20155019, this method is appropriate for ungaged sites on large streams where regression equations are not applicable (e.g. drainage area out of the range of applicability), and results may not be reliable if the ratio of drainage areas (DA_U/DA_G) is outside the range of 0.5 to 1.5. All applications of this methodology on the ungaged sites on the Jefferson River and Beaverhead River meet these criteria. Results are summarized in Table 4.

Equation 1:

$$Q_{AEP,U} = Q_{AEP,G}\left(\frac{DA_U}{DA_G}\right)^{exp_{AEP}}$$

Where:

$Q_{AEP,U}$	is the AEP-percent peak flow for ungaged site *U*, in cubic feet per second;
$Q_{AEP,G}$	is the AEP-percent peak flow for gaging station *G*, in cubic feet per second;
DA_U	is the drainage area at ungaged site *U*, in square miles;
DA_G	is the drainage area at gaging station *G*, in square miles;
exp_{AEP}	is the regression coefficient for an OLS regression relating the log of the AEP-percent peak flow to the log of the drainage area within each location (SIR 20155019 Chapter F, Table 5).

At ungaged sites located between two gaging stations on the same river, Chapter F provides a methodology to estimate peak-flow frequencies using linear interpolation of the logarithms of peak-flow frequencies at the two gages using the logarithm of the drainage areas as the basis for the interpolation. The flow change locations between the two gaging stations on the Jefferson River utilize this methodology. The SIR cautions that this method may produce unreliable results if the two gaging stations have different peak flow characteristics caused by substantially different periods of records. The MOVE.3 analysis performed by USGS (Sando and McCarthy 2018) minimizes the potential for this cause of unreliability given the record extension methodology. Results are presented in Table 4.

Equation 2:

$$logQ_{AEP,U} = logQ_{AEP,G1} + \left[\frac{(logQ_{AEP,G2} - logQ_{AEP,G1})}{(logDA_{G2} - logDA_{G1})}\right](logDA_U - logDA_{G1})$$

where:

$Q_{AEP,U}$	is the AEP-percent peak flow at ungaged site *U*, in cubic feet per second;
$Q_{AEP,G1}$	is the AEP-percent peak flow for the upstream gaging station *G1*, in cubic feet per second;
$Q_{AEP,G2}$	is the AEP-percent peak flow at the downstream gaging station *G2*, in cubic feet per second;
DA_{G2}	is the drainage area at the downstream gaging *G2*, in square miles;
DA_{G1}	is the drainage area at the upstream gaging station *G1*, in square miles; and
D_{AU}	is the drainage area at ungaged site *U*, in square miles.

4.3.2. Regional Regression Equations Method

Three watersheds within the study area do not have stream gage data and regional regression equations area used to estimate the peak flow values for the flows with the recurrence intervals evaluated in this study (10%, 4%, 2%, 1%, 0.2%, and the 1% plus AEPs). The flood frequency analysis was performed using methods presented by the USGS in: Montana StreamStats – A method for retrieving basin and Streamflow characteristics in Montana (McCarthy et al. 2016). StreamStats is a Web-based GIS application created by USGS to provide simple access for users to determine a number of relevant hydrologic characteristics in an area of interest. StreamStats (version 4.2.0) was used to delineate the watersheds, extract relevant information, and perform preliminary hydrologic calculations for the South Boulder River, Mill Creek, and Indian Creek watersheds. As described in Chapter A (McCarthy et al. 2016), StreamStats delineates the basin using the National Hydrography Dataset Plus Version 2 (NHDPlus V2), which primarily utilizes the National Hydrography Dataset stream network, derived hydrologic units ((HUC) 12-digit) from the Watershed Boundary Dataset, and 30-meter digital elevation model (DEM) from the National Elevation Dataset (NED). Following watershed boundary delineation, StreamStats derives a suite of basin characteristics, including those that are used in the regional regression equations and the percentage of the basin subject to upstream flow regulation. None of the ungaged basins evaluated in this study are subject to upstream flow regulation. The watersheds delineated by StreamStats were saved as GIS shapefiles and the basin boundaries were independently verified to ensure they were correctly representing the contributing area for the specific basin. The boundaries were manually adjusted at the lower extents of the Mill Creek and Indian Creek basins where the creeks enter the Ruby River floodplain and the lack of relief in the floodplain resulted in inaccurate basin boundaries near the confluence with the Ruby River. The drainage areas for Indian Creek and Mill Creek were delineated at two locations each:

1) at their respective confluence with, or near, the Ruby River; and
2) at each creek's crossing of Main Street at the Town of Sheridan, MT.

Each drainage's contributing area at the Town of Sheridan were utilized for peak flow determination given the proximity of the two creeks to each other and the Town of Sheridan. The lower portion of Indian Creek required manual adjustment to the watershed boundary to match the Indian Creek flowpath and topographic features that form hydrologic divide between the Indian Creek drainage and adjacent basins. The manual adjustment also relied on interpretation of aerial imagery and the complex flow patterns, as well as small drainage and irrigation ditches result in apparent flowpaths that cross the basin boundaries. However, these flowpaths do not appear to have sufficient conveyance to significantly alter the contributing basin and flow conditions in Indian Creek. Leonard Slough is one of these flowpaths identified on USGS maps as a water body contributing to lower Indian Creek, however, review of available information suggests that properly delineating the Indian Creek drainage results in a boundary that crosses this flowpath.

The South Boulder River watershed was delineated at two locations:

1) the confluence of South Boulder River with the Jefferson River; and
2) where South Boulder River leaves the confined valley near the US Forest Service boundary, approximately 7 miles from the confluence with the Jefferson River.

Chapter F provides methods for estimating peak-flow frequencies at ungaged sites. Regional regression equations were developed for eight hydrologic regions within Montana through regional regression analyses of streamgages within each of the regions. The ungaged watersheds within the Jefferson River watershed study area lies within Southwest Region. Forty-eight streamgages within the Southwest hydrologic region were utilized to develop the regression equations for the region. The regression equations were derived from streamflow data to 2011 and in this region were primarily an update to the 2004 analysis performed by the USGS (Parrett and Johnson 2004) on flow data through 1998, and included the same explanatory variables (contributing drainage area and percent of watershed above 6,000 ft elevation) as the 2004 analysis. Ten regression equations are provided for the southwest hydrologic region covering peak flow estimates with AEPs from 66.7% to 0.2% (1.5-year to 500-year recurrence intervals).

4.4. Regional Regression Equations

Equations for the five recurrence intervals of interest for this study are presented in Table 5 below, along with the resulting flow estimates and basin characteristics for the South Boulder River, Mill Creek, and Indian Creek drainages.

4.5. Twin Bridges Reach of the Beaverhead River

While there is a USGS stream gage on the Beaverhead River in the Twin Bridges reach (06023100), the gage is only operated seasonally (July through September) and has only been in service for a relatively short duration, thus the reach of the Beaverhead River between the Ruby River and the Big Hole River requires an alternate method for evaluating peak flow frequencies. The City of Twin Bridges lies along this approximately five-mile reach of the Beaverhead River. An initial assessment indicates that although implementing the standard method for estimating the peak-flow frequency when an ungaged site is close to a gaging station on the same river and the drainage-area ratio adjustment method might be applicable, this methodology provides unreliable results with flow values in this reach significantly less than the flows values of the smaller Ruby River watershed below the confluence of the two rivers. The reason for the unreasonably low predicted flow values is that the Beaverhead River upstream of the confluence with the Ruby River is highly regulated by upstream reservoirs.

Discussions were held with USGS and DNRC and an alternate methodology was applied to the Twin Bridges reach of the Beaverhead River. The methodology applied to the Beaverhead River in the Twin Bridges reach is as follows:

- The Jefferson River forms at the confluence of the Beaverhead and Big Hole Rivers. There are USGS gaging stations on the Big Hole River and the Jefferson River near the confluence of the Beaverhead River and Jefferson River. Mean daily flow values for the Big Hole River were subtracted from the mean daily flow values for the Jefferson River to estimate mean daily flows on the Beaverhead River in the Twin Bridges reach.
- Annual peak daily flow values for the Beaverhead River in the Twin Bridges reach were determined for each of the years with concurrent Big Hole River and Jefferson River flows. This resulted in 19 years of peak daily flow data for the Beaverhead River in the Twin Bridges reach. The annual peak daily flows for the Twin Bridges reach represent differences in flows and no adjustment to instantaneous peak flows was needed as this adjustment would have been similar for the Big Hole and Jefferson Rivers.
- A log Pearson type III analysis was performed on the calculated annual peak flows for the Twin Bridges reach of the Beaverhead River following Bulletin 17C procedures. Flow values were determined for the 10%, 4%, 2%, 1%, and 0.2% AEPs. Using the calculated variance for the 1% AEP analysis, the 1% 'plus' flow value was determined.

The results of the calculated flow values for the Twin Bridges reach of the Beaverhead River are reported in Table 4. Supporting documentation for Twin Bridges reach of the Beaverhead River are provided in Appendix C.

5. Summary/Discussion

This peak flow frequency analysis was performed for the Jefferson River and tributaries in the Jefferson River watershed primarily in Gallatin and Madison Counties. In addition to the Jefferson River, the analyses include the Beaverhead River to the Madison – Beaverhead County line, the Ruby River to the gaging station immediately upstream of the Ruby Reservoir, and South Boulder River (tributary to the Jefferson River), Indian Creek (tributary to the Ruby River), and Mill Creek (tributary to the Ruby River) - all of which are in in Madison County. The peak flow frequency analyses were performed for the flows that correspond to the 10%, 4%, 2%, 1%, and 0.2% AEPs. In addition to these

AEPs, the 1%plus discharge value was determined at each flow node, which incorporates a standard error of prediction into the 1% AEP calculations. Figure 16 provides a summary of recommended 1% AEP flow values at all Jefferson River watershed flow nodes.

The peak flow frequency analyses were performed by the USGS on select USGS stream flow gages on the Jefferson River (06036650 and 06026500), Beaverhead River (06018500), and Ruby River (06023000, 06022000, 06021500, 06020600, and 06019500). These analyses were performed on stream gage peak flow data through 2016, and update the flood-frequency analysis performed on these gages by the USGS in 2015 (Sando et al. 2018a), which used peak flow data through 2011.

For the Jefferson River at Three Forks, the 2016 analysis resulted in 1,500 cfs increase over the calculations on data through year 2011. The likely reason for this is the record extension method applied in the 2016 analysis, which greatly increased the number of peak flows used in the analysis (111 records for 2016 versus 47 records in the analysis of data through 2011). The record extension and analysis methods for 2016 data included peak events prior to 1965, which was when Clark Canyon Dam was closed and began regulating Beaverhead River flows. The analyses on data through year 2011 excluded those earlier data, and several peaks prior to 1965 approached or exceeded a 25-year flood event. The analysis on data through 2016 results in significantly lower peak-flood values than those currently reported in the effective FIS (21,700 cfs using data to 2016 versus 27,600 cfs for the 1% AEP in the FIS). The longer period of record and advanced statistical methods are the likely factors for the significant reduction in peak-flow frequency results. The peak flow frequency estimates from the 2016 data for the Jefferson River at Twin Bridges also result in larger flow values than the analyses using data through 2011. As with the analysis for the Three Forks gage, the Twin Bridges analysis includes a substantially greater number of peak flow values than the analysis of data through 2011 analysis (111 records for 2016 versus 47 records in the 2011 analysis). At the Twin Bridges gage, the 1% AEP for 2016 data analysis is 18,800, an increase of 2,000 cfs from the 16,800 cfs determined through the analysis through 2011.

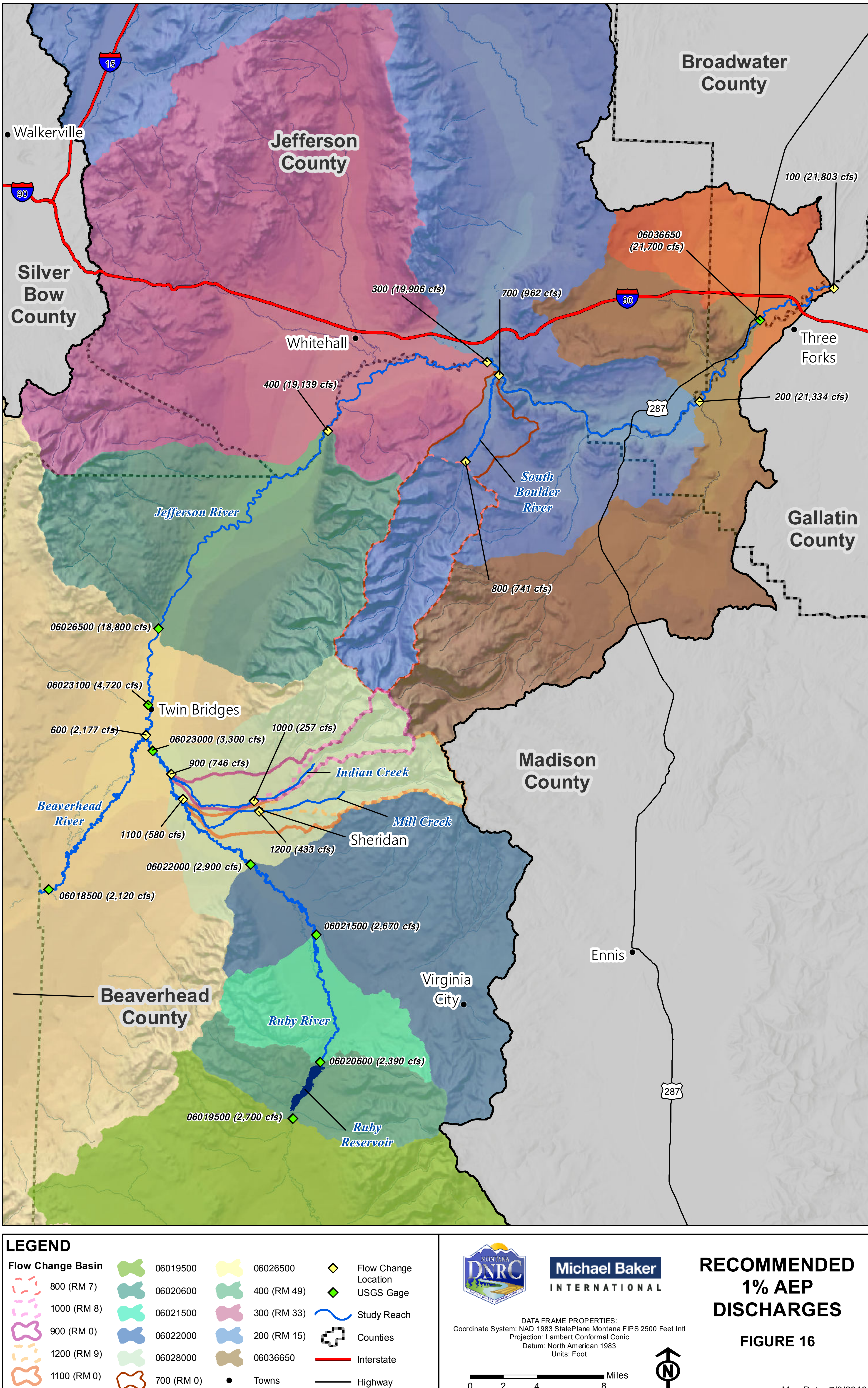
The difference in analysis results between the 2011 data and 2016 data at the Beaverhead River near Twin Bridges (06018500) is less pronounced than on the Jefferson River. At this site, the 2016 analysis produced a slightly larger 1% AEP value (2,120 cfs) than the analysis using data through 2011 (2,080 cfs). The small difference in values is likely a result of the same analysis methods applied to the gaging station with just an increase of five records for the 2016 analysis (e.g. the additional five years of data since 2011).

For the Ruby River gaging stations, the differences between the analysis using 2016 data are generally minor with some relatively small increases and decreases in values for the various AEPs. A comparison of the 1% AEP between the two analyses resulted in two of the four to gaging stations resulting in small increases in estimated peak flow values (06023000 and 06019500 increased 70 cfs and 100 cfs, respectively), while the other two sites (06021500 and 06020600) had decreases in estimated peak flow values (290 cfs and 40 cfs, respectively). As with previous analyses, Ruby Reservoir appears to attenuate peak flow events, as the peak-flow frequency analyses for the gage above the Ruby Reservoir are greater than the peak-flow values for the first gaging stations downstream of the reservoir.

To appropriately represent flow conditions through the Jefferson River and Beaverhead River study reaches, flow change locations were identified within the reach and drainage area-based gage transfer methodologies were utilized to establish peak flow frequency values at these flow change locations. It was determined that the gaging stations on the Ruby River were sufficiently close to one another to adequately describe flow changes between the Ruby Reservoir and confluence with the Beaverhead River so intermediate flow change locations are not necessary.

There are no stream flow gages on South Boulder River, Indian Creek, and Mill Creek; thus, peak flow frequency calculations were performed using regional regression equation methods for determine flood frequency at ungaged sites. These water bodies drain relatively small watersheds, that are relatively high in elevation and have considerable topographic relief until they reach the Jefferson River and Ruby River floodplains. USGS has developed regional regression equations for the various hydrologic regions across the State of Montana. The Jefferson River watershed lies in the southwest region and the regression equations specific to this region were used in this analysis. The watershed basins were delineated using USGS StreamStats web application and inspected and modified to ensure watershed boundaries were delineated correctly. A separate, smaller sub-basin was delineated within each watershed that provides a better representation of calculated flows as the basin exits the relatively confined valley or canyon prior to transitioning to a broader valley and floodplain of the larger river. In the case of Indian Creek and Mill Creek, the transition occurs near the Town of Sheridan and provides a reasonable estimate of the potential flow values at Sheridan. As expected, the size of the watershed is the major factor for the flow calculations, and the larger watersheds have higher values for the peak-flow frequency values.

Table 4 summarizes the results of the analyses performed for this study and provides the flow recommendations at select USGS gaging stations, intermediate flow change locations, and locations within ungaged watersheds.



Broadwater County
Jefferson County
Walkerville
Silver Bow County
Whitehall
Three Forks
Gallatin County
Madison County
Twin Bridges
Sheridan
Ennis
Virginia City
Beaverhead County
100 (21,803 cfs)
06036650 (21,700 cfs)
300 (19,906 cfs)
700 (962 cfs)
400 (19,139 cfs)
200 (21,334 cfs)
South Boulder River
Jefferson River
800 (741 cfs)
06026500 (18,800 cfs)
06023100 (4,720 cfs)
600 (2,177 cfs)
06023000 (3,300 cfs)
1000 (257 cfs)
900 (746 cfs)
Indian Creek
Mill Creek
Beaverhead River
1100 (580 cfs)
1200 (433 cfs)
06022000 (2,900 cfs)
06018500 (2,120 cfs)
06021500 (2,670 cfs)
Ruby River
06020600 (2,390 cfs)
06019500 (2,700 cfs)
Ruby Reservoir
15
90
287
LEGEND
Flow Change Basin
800 (RM 7)
1000 (RM 8)
900 (RM 0)
1200 (RM 9)
1100 (RM 0)
06019500
06020600
06021500
06022000
06028000
700 (RM 0)
06026500
400 (RM 49)
300 (RM 33)
200 (RM 15)
06036650
Towns
Flow Change Location
USGS Gage
Study Reach
Counties
Interstate
Highway
Michael Baker INTERNATIONAL
DATA FRAME PROPERTIES:
Coordinate System: NAD 1983 StatePlane Montana FIPS 2500 Feet Intl
Projection: Lambert Conformal Conic
Datum: North American 1983
Units: Foot
0 2 4 8 Miles
RECOMMENDED 1% AEP DISCHARGES
FIGURE 16
Map Date: 7/3/2018

6. References

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Appendix A.

Historic Flood Photos

Photo 1. Jefferson River (right) and Madison River (left) at Confluence. June 2011.

Photo 2. Jefferson River below Three Forks, MT. June 2011.

Photo 3. Jefferson River at Three Forks, MT. June 2011.

Photo 4. Jefferson River above Three Forks, MT. June 2011.

Photo 5. Jefferson River above Three Forks – Jefferson River Rd. June 2011.

Photo 6. Jefferson River above Three Forks – off of Hwy 285. June 2011.

Photo 7. Jefferson River above Three Forks. June 2011.

Photo 8. Jefferson River near Willow Creek, MT. June 2011.

Photo 9. Jefferson River near Cardwell, MT. June 2011.

Photo 10. Jefferson River at Cardwell, MT. June 2011.

Photo 11. Jefferson River near Three Forks, MT and Hwy 287. June 1948.

Photo 12. Jefferson River near Three Forks, MT and Hwy 287. June 1948.

Photo 13. Collection of photographs from 1948 flood near Three Forks, MT. June 1948. Courtesy of City of Three Forks.

Photo 14. Jefferson River near Three Forks, MT. June 1948.

Photo 15. Jefferson River near Three Forks, MT. June 1948.

Photo 16. Ice Jam near Twin Bridges, MT. January 2011.

Photo 17. Ice Jam at Jefferson Acres near Twin Bridges, MT. January 2011.

Photo 18. Jefferson River near Twin Bridges, MT. June 1997.

Photo 19. Jefferson River near Silver Star, MT. June 1997.

Photo 20. Jefferson River below Silver Star, MT. June 1997.

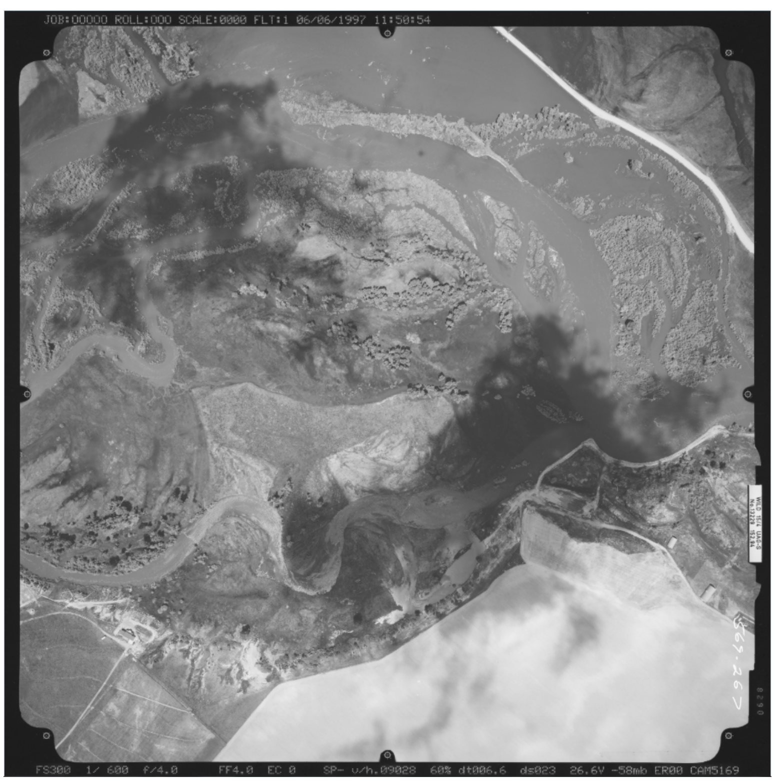

Photo 21. Jefferson River near Whitehall, MT. June 1997.

Photo 22. Jefferson River near Cardwell, MT. June 1997.

Photo 23. Jefferson River near Willow Creek, MT. June 1997.

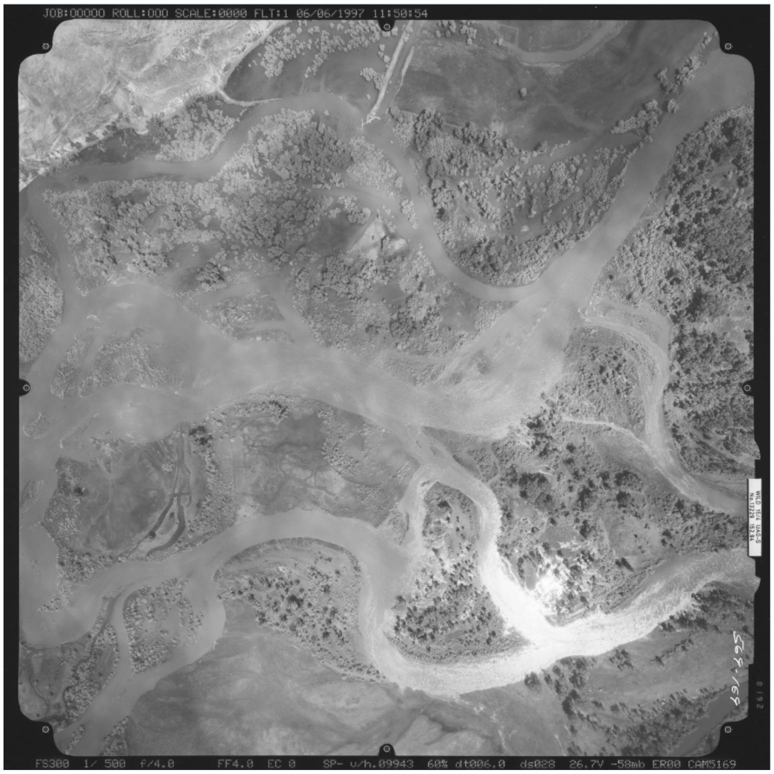

Photo 24. Jefferson River near Three Forks, MT. June 1997.

Photo 25. Jefferson River below Three Forks, MT. June 1997.

Photo 26. Beaverhead River ice jam near Twin Bridges, MT. January 2011.

Photo 27. Beaverhead River ice jam near Twin Bridges, MT. January 2011.

Photo 28. Beaverhead River ice jam near Twin Bridges, MT. January 2011.

Photo 29. Beaverhead River ice jam at Twin Bridges, MT. January 2011.

Photo 30. Beaverhead River ice jam at Twin Bridges, MT. January 2011.

Photo 31. Beaverhead River ice jam flood protection at Twin Bridges, MT. January 2011.

Photo 32. Ice Jam at Jefferson Acres near Twin Bridges, MT. February 2011.

Photo 33. Ice Jam at Jefferson Acres near Twin Bridges, MT. February 2011.

Appendix B.

USGS Stream Gage Analyses

Table 1–1. Information on streamgages for which peak-flow frequency analyses are reported.

[Water year is the 12-month period from October 1 through September 30 and is designated by the year in which it ends. NAD 83, North American Datum of 1983; --, not applicable; U, unregulated; ND, not determined; R, regulated]

Map number (fig. 1)	Streamgage identification number	Streamgage name	Latitude, in decimal degrees (NAD 83)	Longitude, in decimal degrees (NAD 83)	Type of streamgage[1]	Contributing drainage area, in square miles	Data combination[2]	Data correction[3]	Regulation status[4] as of 2014	Number of recorded peak flows	Water years of recorded peak flows	Number of unregulated peak-flow records	Water years of unregulated peak-flow records	Number of regulated peak-flow records	Water years of regulated peak-flow records	Percentage of drainage basin regulated by dams	Regulation status for reported at-site peak-flow frequency analyses
31	06018500	Beaverhead River near Twin Bridges, Montana	45.3834	-112.4528	CONT	3,618	--	--	R (MAJ–dam)	80	1936–44, 1946–2016	28	1936–64	52	1965–2016	65	R
33	06019500	Ruby River above reservoir, near Alder, Montana	45.1923	-112.1428	CONT	534	--	--	U	78	1939–2016	78	1939–2016	0	--	0	U
35	06020600	Ruby River below reservoir, near Alder, Montana	45.2419	-112.1112	CONT	595	--	--	R (MAJ–dam)	54	1963–2016	0	--	54	1963–2016	100	R
37	06021500	Ruby River at Laurin, Montana	45.3525	-112.1225	CONT	643	--	--	R (MAJ–dam)	14	1947–60	0	--	14	1947–60	92	R
37B	06022000	Ruby River below Ramshorn Creek, near Sheridan, Montan	45.4113	-112.2058	CONT	839	Yes	--	R (MAJ–dam)	26	1947–53, 1997–2011, 2013–16	0	--	26	1947–53, 1997–2011, 2013–16	71	R
38	06023000	Ruby River near Twin Bridges, Montana	45.5069	-112.3309	CONT	970	--	--	R (MAJ–dam)	25	1942–43, 1947–65, 1980–81, 2015–16	0	--	25	1942–43, 1947–65, 1980–81, 2015–16	62	R
48	06026500	Jefferson River near Twin Bridges, Montana	45.6133	-112.3294	CONT	7,616	Yes	--	R (MAJ–dam)	65	1911–16, 1921–39, 1942–43, 1958–72, 1994–2016	34	1911–16, 1921–39, 1942–43, 1958–64	31	1965–72, 1994–2016	40	R, Total
64	06036650	Jefferson River near Three Forks, Montana	45.8971	-111.5957	CONT	9,558	Yes	--	R (MAJ–dam)	80	1895, 1897–1905, 1939–69, 1975, 1979–2016	36	1895, 1897–1905, 1939–64	44	1965–69, 1975, 1979–2016	34	R, Total
69	06037500	Madison River near West Yellowstone, Montana	44.6571	-111.0680	CONT	435	--	--	U	90	1914–17, 1919–73, 1984–86, 1989–2016	90	1914–17, 1919–73, 1984–86, 1989–2016	0	--	0	U
70	06038500	Madison River below Hebgen Lake, near Grayling, Montan	44.8664	-111.3388	CONT	931	--	Yes	R (MAJ–dam)	75	1940–58, 1960–67, 1969–2016	19	1940–58	56	1960–67, 1969–2016	100	R
72	06038800	Madison River at Kirby Ranch, near Cameron, Montana	44.8887	-111.5809	CONT	1,092	--	--	R (MAJ–dam)	35	1960–61, 1963, 1985–2016	0	--	35	1960–61, 1963, 1985–2016	94	R
73	06040000	Madison River near Cameron, Montana	45.2331	-111.7516	CONT	1,665	--	--	R (MAJ–dam)	20	1952–58, 1960–63, 1968–70, 2011–16	0	--	20	1952–58, 1960–63, 1968–70, 2011–16	61	R
75	06041000	Madison River below Ennis Lake, near McAllister, Montan	45.4902	-111.6345	CONT	2,150	--	--	R (MAJ–dam)	77	1939–2016	0	--	77	1939–2015	98	R
76	06042500	Madison River near Three Forks, Montana	45.8236	-111.4997	CONT	2,453	--	--	R (MAJ–dam)	16	1894–96, 1929–32, 1942–50	3	1894–96	13	1929–32, 1942–50	87	R

[1]Abbreviations for type of streamgage are defined as follows:
CONT: continuous streamflow operations.
CSG: crest-stage gage operations.
In cases where both CONT and CSG are indicated for an individual streamgage, the historic operations of the streamgage have included periods of continuous streamflow operations and periods of crest-stage gage operations.

[2]Data combination refers to combining peak-flow records of two or more closely located streamgages on the same channel. Information on combining records of multiple streamgages is presented in table 1–2.

[3]Data correction refers to manual adjustment of specific peak-flow records to provide reliable frequency analyses. Information on manual correction of peak-flow records is presented in table 1–3.

[4]Abbreviations for regulation status are defined as follows:
U, unregulated, where the cumulative drainage area upstream from all dams is less than 20 percent of the drainage area of the streamgage.
R (MAJ–dam): major dam regulation, where a single upstream dam has a drainage area that exceeds 20 percent of the drainage area of the streamgage.
R (MAJ–canal): major diversion canal regulation, where a large diversion canal is known to be located on the channel upstream from the streamgage.
R (MIN–dams): minor dam regulation, where the cumulative drainage area of all upstream dams exceeds 20 percent of the drainage area of the streamgage, but no single upstream dam has a drainage area that exceeds 20 percent of the drainage area of the streamgage.
Total: the combined unregulated and regulated peak-flow records for streamgages with peak-flow records before and after the start of regulation, . The "Total" peak-flow frequency analysis is provided in cases where major regulation affects less than 50 percent of the drainage area of the streamgage and there is uncertainty in the effects of regulation on specific peak-flow characteristics. Also, the "Total" peak-flow frequency analysis is the only peak-flow frequency analysis provided in cases of minor dam regulation.

Table 1–4. Documentation regarding analytical procedures for peak-flow frequency analyses

[Water year is the 12-month period from October 1 through September 30 and is designated by the year in which it ends. PILF, potentially influential low flow; U, unregulated; --, not applicable; R, regulated; BP, base period used in the Maintenance of Variance Extension Type III record extension]

Map number (fig. 1)	Streamgage identification number and analysis designation[1]	Streamgage name	Contributing drainage area, in square miles	Regulation status for analysis[2]	Type of peak-flow frequency analysis[3]	Number of peak flows used in the analysis	Water years of peak flows used in the analysis	Primary reason for deviation from standard Bulletin 17C procedures[4]	Log-distribution information for peak-flow data							PILF information				Frequency analysis incorporates historical information? (if yes, see Table 1-5 for additional information)
									Mean	Standard deviation	Skew type used in analysis	Station skew of the peak-flow data	Generalized skew	Source of generalized skew used in weighted skew determinations	Analysis skew used for the frequency analysis	PILF threshold, cubic feet per second	Type of PILF threshold	Number of systematic peak flows equal to zero	Number of systematic peak flows less than PILF threshold	
31	06018500.10	Beaverhead River near Twin Bridges, Montana	3,618	R (MAJ–dam)	At-site	52	1965–2016	--	2.840	0.215	Weighted	-0.056	-0.192	Bulletin 17B[5]	-0.083	--	MGBT	0	0	--
33	06019500.00	Ruby River above reservoir, near Alder, Montana	534	U	At-site	78	1939–2016	upper tail	2.989	0.158	Station	0.658	-0.205	--	0.658	537	Manual	0	1	Yes
35	06020600.10	Ruby River below reservoir, near Alder, Montan	595	R (MAJ–dam)	At-site	54	1963–2016	reg	2.964	0.182	Station	0.090	-0.188	--	0.090	--	MGBT	0	0	Yes
35	06020600.11	Ruby River below reservoir, near Alder, Montan	595	R (MAJ–dam)	MOVE.3	78	BP 1939–2016	reg	2.936	0.177	Station	0.237	-0.188	--	0.237	--	MGBT	0	0	Yes
37	06021500.10	Ruby River at Laurin, Montana	643	R (MAJ–dam)	At-site	14	1947–60	reg	2.551	0.261	Station	-0.285	-0.159	--	-0.285	--	MGBT	0	0	--
37	06021500.11	Ruby River at Laurin, Montana	643	R (MAJ–dam)	MOVE.3	78	BP 1939–2016	reg	2.584	0.347	Station	0.146	-0.159	--	0.146	--	MGBT	0	0	Yes
37B	06022000.10	Ruby River below Ramshorn Creek, near Sheridan, Montana	839	R (MAJ–dam)	At-site	26	1947–53, 1997–2011, 2013–16	--	2.701	0.304	Weighted	0.318	-0.154	Bulletin 17B[5]	0.047	--	MGBT	0	0	--
37B	06022000.11	Ruby River below Ramshorn Creek, near Sheridan, Montana	839	R (MAJ–dam)	MOVE.3	78	BP 1939–2016	--	2.722	0.309	Weighted	0.149	-0.154	Bulletin 17B[5]	0.099	--	MGBT	0	0	Yes
38	06023000.10	Ruby River near Twin Bridges, Montana	970	R (MAJ–dam)	At-site	25	1942–43, 1947–65, 1980–81, 2015–16	--	2.806	0.222	Weighted	-0.176	-0.148	Bulletin 17B[5]	-0.160	--	MGBT	0	0	--
38	06023000.11	Ruby River near Twin Bridges, Montana	970	R (MAJ–dam)	MOVE.3	78	BP 1939–2016	--	2.839	0.280	Weighted	0.195	-0.148	Bulletin 17B[5]	0.138	--	MGBT	0	0	Yes
48	06026500.10	Jefferson River near Twin Bridges, Montana	7,616	R (MAJ–dam)	At-site	31	1965–72, 1994–2016	--	3.930	0.149	Weighted	-0.516	-0.123	Bulletin 17B[5]	-0.241	7,530	MGBT	0	11	--
48	06026500.11	Jefferson River near Twin Bridges, Montana	7,616	R (MAJ–dam)	MOVE.3	52	BP 1965–2016	--	3.917	0.158	Weighted	-0.699	-0.123	Bulletin 17B[5]	-0.330	7,530	MGBT	0	20	--
48	06026500.20	Jefferson River near Twin Bridges, Montana	7,616	Total	At-site	65	1911–16, 1921–39, 1942–43, 1958–72, 1994–2016	--	3.896	0.197	Weighted	-1.004	-0.123	Bulletin 17B[5]	-0.420	6,050	MGBT	0	18	--
48	06026500.21	Jefferson River near Twin Bridges, Montana	7,616	Total	MOVE.3	111	BP 1895, 1897–1905, 1911–16, 1921–26, 1928–2016	--	3.906	0.180	Weighted	-0.611	-0.123	Bulletin 17B[5]	-0.379	6,820	MGBT	0	37	--
64	06036650.10	Jefferson River near Three Forks, Montana	9,558	R (MAJ–dam)	At-site	44	1965–69, 1975, 1979–2016	--	3.908	0.210	Weighted	-1.130	0.078	Bulletin 17B[5]	-0.205	7,220	MGBT	0	18	Yes
64	06036650.11	Jefferson River near Three Forks, Montana	9,558	R (MAJ–dam)	MOVE.3	52	BP 1965–2016	--	3.964	0.166	Weighted	-0.590	0.078	Bulletin 17B[5]	-0.178	8,430	MGBT	0	21	--
64	06036650.20	Jefferson River near Three Forks, Montana	9,558	Total	At-site	80	1895, 1897–1905, 1939–69, 1975, 1979–2016	--	3.919	0.205	Weighted	-0.981	0.078	Bulletin 17B[5]	-0.286	6,910	MGBT	0	28	Yes
64	06036650.21	Jefferson River near Three Forks, Montana	9,558	Total	MOVE.3	111	BP 1895, 1897–1905, 1911–16, 1921–26, 1928–2016	--	3.948	0.184	Weighted	-0.606	0.078	Bulletin 17B[5]	-0.283	7,610	MGBT	0	39	--
69	06037500.00	Madison River near West Yellowstone, Montana	435	U	At-site	90	1914–17, 1919–73, 1984–86, 1989–2016	--	3.134	0.124	Weighted	0.146	-0.145	Bulletin 17B[5]	0.103	--	MGBT	0	0	Yes
70	06038500.10	Madison River below Hebgen Lake, near Grayling, Montan	931	R (MAJ–dam)	At-site	56	1960–67, 1969–2016	reg	3.366	0.129	Station	0.184	-0.142	--	0.184	--	MGBT	0	0	--
72	06038800.10	Madison River at Kirby Ranch, near Cameron, Montan	1,092	R (MAJ–dam)	At-site	35	1960–61, 1963, 1985–2016	reg	3.426	0.175	Station	-0.013	-0.181	--	-0.013	--	MGBT	0	0	--
72	06038800.11	Madison River at Kirby Ranch, near Cameron, Montan	1,092	R (MAJ–dam)	MOVE.3	57	BP 1960–2016	reg	3.449	0.164	Station	-0.056	-0.181	--	-0.056	--	MGBT	0	0	--
73	06040000.10	Madison River near Cameron, Montana	1,665	R (MAJ–dam)	At-site	13	1960–63, 1968–70, 2011–16	--	3.625	0.197	Weighted	-0.521	-0.134	Bulletin 17B[5]	-0.215	--	MGBT	0	0	--
73	06040000.11	Madison River near Cameron, Montana	1,665	R (MAJ–dam)	MOVE.3	57	BP 1960–2016	--	3.631	0.174	Weighted	-0.312	-0.134	Bulletin 17B[5]	-0.274	--	MGBT	0	0	--
75	06041000.10	Madison River below Ennis Lake, near McAllister, Montan	2,150	R (MAJ–dam)	At-site	57	1960–2016	reg	3.670	0.154	Station	-0.274	-0.041	--	-0.274	--	MGBT	0	0	--
76	06042500.11	Madison River near Three Forks, Montan	2,453	R (MAJ–dam)	MOVE.3	57	BP 1960–2016	reg	3.675	0.158	Station	-0.286	0.072	--	-0.286	--	MGBT	0	0	--

[1]The streamgage identification number and analysis designation is defined by XXXXXXXX.AB,
where,
XXXXXXXX is the streamgage identification number;
A is the regulation status for the analysis period; and
B is the type of peak-flow frequency analysis.

Values of A (regulation status) are defined as:
A = 0, unregulated;
A = 1, regulated by major regulation; and
A =2, total; that is, the combined unregulated and regulated peak-flow records for streamgages with peak-flow records before and after the start of regulation (see footnote 2).

Values of B (type of peak-flow frequency analysis) are defined as:
B = 0, at-site peak-flow frequency analysis conducted on recorded data;
B = 1, peak-flow frequency analysis conducted on combined recorded and synthesized data; synthesized data from Maintenance of Variance Extension Type III (MOVE.3) record extension procedure;
B =2, peak-flow frequency analysis determined from regional regression equations (RREs); RRE frequency results not presented in this report; and
B = 3, at-site peak-flow frequency analysis weighted with results from RREs; distributional parameters not available for RRE weighted frequency analyses.

[2]Abbreviations for regulation status are defined as follows:
U, unregulated, where the cumulative drainage area upstream from all dams is less than 20 percent of the drainage area of the streamgage.
R (MAJ–dam): major dam regulation, where a single upstream dam has a drainage area that exceeds 20 percent of the drainage area of the streamgage.
R (MAJ–canal): major diversion canal regulation, where a large diversion canal is known to be located on the channel upstream from the streamgage.
R (MIN–dams): minor dam regulation, where the cumulative drainage area of all upstream dams exceeds 20 percent of the drainage area of the streamgage, but no single upstream dam has a drainage area that exceeds 20 percent of the drainage area of the streamgage.
Total: the combined unregulated and regulated peak-flow records for streamgages with peak-flow records before and after the start of regulation, . The "Total" peak-flow frequency analysis is provided in cases where major regulation affects less than 50 percent of the drainage area of the streamgage and there is uncertainty in the effects of regulation on specific peak-flow characteristics. Also, the "Total" peak-flow frequency analysis is the only peak-flow frequency analysis provided in cases of minor dam regulation.

[3]Abbreviations for type of frequency analysis are defined as follows:
At-site: peak-flow frequency analysis on recorded data.
RRE wtd: the at-site peak-flow frequency analysis was weighted with results from regional regression equations (RREs).
MOVE.3: peak-flow frequency analysis on combined recorded and synthesized data; synthesized data from Maintenance of Variance Extension Type III (MOVE.3) record extension procedure.

[4]Standard Bulletin 17C (England and others, 2017) procedures are considered to be the use of the weighted skew and the use of the multiple Grubbs-Beck low-outlier test (MGBT) for identifying PILFs. In cases where either the station skew or a manual (analyst-selected) PILF threshold was used, the peak-flow frequency analysis was considered to deviate from standard Bulletin 17C procedures. The abbreviations for the reasons for deviation from standard Bulletin 17C procedures are defined as follows:
reg: the peak-flow records are affected by major dam or canal regulation;
upper tail: the probability plots of the peak-flow records deviate from typical patterns in the upper tail of the frequency curve, generally because of mixed population characteristics; and
lower tail: the probability plots of the peak-flow records deviate from typical patterns in the lower tail of the frequency curve at high annual exceedance probabilities (greater than about 50.0 percent).
[5]U.S. Interagency Advisory Council on Water Data, 1982, Guidelines for determining flood flow frequency: Hydrology Subcommittee, Bulletin 17B, appendixes 1–14, 28 p.

Table 1–6. Documentation regarding the Maintenance of Variance Extension Type III (MOVE.3) record extension procedure for selected streamgages.

[Water year is the 12-month period from October 1 through September 30 and is designated by the year in which it ends. --, not applicable]

Target streamgage for which peak flows were synthesized									Index streamgage(s) used for synthesis of peak flows								
Map number (fig. 1)	Streamgage identification number	Streamgage Name	Contributing drainage area, in square miles	Number of recorded peak flows	Water years of recorded peak flows	Number of years requiring synthesis of peak flows	Water years requiring synthesis of peak flows	Percentage of record synthesized	Streamgage identification number	Streamgage Name	Contributing drainage area, in square miles	Number of peak flows synthesized based on this streamgage	Number of concurrent recorded peak flows for target and index streamgages	Pearson correlation coefficient for concurrent peak flows for target and index streamgages	Weighted average Pearson correlation coefficient[1]	Estimated[2] standard error of MOVE.3 analysis, in percent	Effective record length for the synthesized peak flows, in years
Streamgages on the Ruby River—base period 1939–2016 (78 years)																	
35	06020600	Ruby River below reservoir, near Alder, Montana	595	54	1963–2016	24	1939–62	30.8	06019500	Ruby River above reservoir, near Alder, Montana	534	24	54	0.87	0.87	24.4	11.5
37	06021500	Ruby River at Laurin, Montana	643	14	1947–60	64	1939–46, 1961–2016	82.1	06019500	Ruby River above reservoir, near Alder, Montana	534	38	14	0.87	0.90	26.1	22.7
									06022000	Ruby River below Ramshorn Creek, near Sheridan, Montana	839	19	7	0.98			
									06023000	Ruby River near Twin Bridges, Montana	970	7	14	0.90			
37B	06022000	Ruby River below Ramshorn Creek, near Sheridan, Montana	839	26	1947–53, 1997–2011, 2013–16	52	1939–46, 1954–96, 2012	66.7	06019500	Ruby River above reservoir, near Alder, Montana	534	8	26	0.73	0.82	45.5	15.8
									06020600	Ruby River below reservoir, near Alder, Montana	595	30	19	0.77			
									06021500	Ruby River at Laurin, Montana	643	7	7	0.98			
									06023000	Ruby River near Twin Bridges, Montana	970	7	9	0.96			
38	06023000	Ruby River near Twin Bridges, Montana	970	25	1942–43, 1947–65, 1980–81, 2015–16	53	1939–41, 1944–46, 1966–79, 1982–2014	67.9	06019500	Ruby River above reservoir, near Alder, Montana	534	36	25	0.73	0.80	31.7	13.6
									06022000	Ruby River below Ramshorn Creek, near Sheridan, Montana	839	17	9	0.96			
Streamgages on the Jefferson River																	
Regulated base period 1965–2016 (52 years)																	
48	06026500	Jefferson River near Twin Bridges, Montana	7,616	65	1911–16, 1921–39, 1942–43, 1958–72, 1994–2016	21	1973–93	40.4	06025500	Big Hole River near Melrose, Montana	2,472	5	31	0.98	0.99	9.0	19.3
									06036650	Jefferson River near Three Forks, Montana	9,558	16	28	0.99			
64	06036650	Jefferson River near Three Forks, Montana	9,558	80	1895, 1897–1905, 1939–69, 1975, 1979–2016	8	1970–74, 1976–78	15.4	06025500	Big Hole River near Melrose, Montana	2,472	5	44	0.97	0.98	15.0	7.2
									06026500	Jefferson River near Twin Bridges, Montana	7,616	3	28	0.99			
Total base period 1895, 1897–1905, 1911–16, 1921–26, 1928–2016 (111 years)																	
48	06026500	Jefferson River near Twin Bridges, Montana	7,616	64	1911–16, 1921–26, 1928–39, 1942–43, 1958–72, 1994–2016	47	1895, 1897–1905, 1940–41, 1944–57, 1973–93	42.3	06025500	Big Hole River near Melrose, Montana	2,472	5	31	0.98	0.99	8.8	41.5
									06036650	Jefferson River near Three Forks, Montana	9,558	42	38	0.99			
64	06036650	Jefferson River near Three Forks, Montana	9,558	80	1895, 1897–1905, 1939–69, 1975, 1979–2016	31	1911–16, 1921–26, 1928–38, 1970–74, 1976–78	27.9	06025500	Big Hole River near Melrose, Montana	2,472	5	44	0.97	0.98	9.6	27.8
									06026500	Jefferson River near Twin Bridges, Montana	7,616	26	38	0.99			
Streamgages on the Madison River—base period 1960–2016 (57 years)																	
72	06038800	Madison River at Kirby Ranch, near Cameron, Montana	1,092	35	1960–61, 1963, 1985–2016	22	1962, 1964–84	38.6	06041000	Madison River below Ennis Lake, near McAllister, Montana	2,150	22	34	0.90	0.90	19.2	11.4
73	06040000	Madison River near Cameron, Montana	1,665	20	1952–58, 1960–63, 1968–70, 2011–16	44	1964–67, 1971–2010	77.2	06041000	Madison River below Ennis Lake, near McAllister, Montana	2,150	44	12	0.98	0.98	8.7	30.0
76	06042500	Madison River near Three Forks, Montana	2,453	16	1894–96, 1929–32, 1942–50	57	1960–2016	100.0	06038500	Madison River below Hebgen Lake, near Grayling, Montana	931	1	9	0.84	0.98	5.4	39.8
									06041000	Madison River below Ennis Lake, near McAllister, Montana	2,150	56	9	0.99			

[1]The weighted average Pearson correlation coefficient was determined by multiplying the number of peak flows synthesized based on an index streamgage times the Pearson correlation coefficent for the index streamgage for each index streamgage. The resultant products then were summed and divided by the total number of synthesized peak flows.

[2]A standard error was calculated based on an ordinary least squares (OLS) formulation of the analysis. That OLS standard error was adjusted to an estimated MOVE.3 formulation by multiplying times the following adjustment factor (Wilbert O. Thomas, Michael Baker International, written commun., November 2016):

$AF_{SE} = (2/[1+\rho])$^0.5,

where,

AF_{SE} is the adjustment factor; and

ρ is the weighted average Pearson correlation coefficient.

Table 1–7. Peak-flow frequency results.

[Water year is the 12-month period from October 1 through September 30 and is designated by the year in which it ends. U, unregulated; R, regulated; --, not applicable; BP, base period used in the Maintenance of Variance Extension Type III record extension]

Map number (fig. 1)	Streamgage identification number and analysis designation[1]	Streamgage name	Contributing drainage area, in square miles	Regulation status for analysis[2]	Type of peak-flow frequency analysis[3]	Number of peak flows used in the analysis	Water years of peak flows used in the analysis	Frequency analysis incorporates historical information? (if yes, see Table 1-5 for additional information)	Annual peak flow, in cubic feet per second, for indicated annual exceedance probability, in percent								
									50	42.9	20	10	4	2	1	0.5	0.2
31	06018500.10	Beaverhead River near Twin Bridges, Montana	3,618	R (MAJ–dam)	At-site	52	1965–2016	--	696	760	1,050	1,300	1,620	1,870	2,120	2,380	2,730
33	06019500.00	Ruby River above reservoir, near Alder, Montana	534	U	At-site	78	1939–2016	Yes	938	1,000	1,300	1,580	1,990	2,330	2,700	3,120	3,730
35	06020600.10	Ruby River below reservoir, near Alder, Montana	595	R (MAJ–dam)	At-site	54	1963–2016	Yes	916	987	1,310	1,580	1,950	2,230	2,520	2,820	3,230
35	06020600.11	Ruby River below reservoir, near Alder, Montana	595	R (MAJ–dam)	MOVE.3	78	BP 1939–2016	Yes	849	914	1,210	1,470	1,820	2,100	2,390	2,700	3,130
37	06021500.10	Ruby River at Laurin, Montana	643	R (MAJ–dam)	At-site	14	1947–60	--	366	407	594	754	960	1,120	1,270	1,430	1,640
37	06021500.11	Ruby River at Laurin, Montana	643	R (MAJ–dam)	MOVE.3	78	BP 1939–2016	Yes	376	434	746	1,080	1,610	2,100	2,670	3,340	4,400
37B	06022000.10	Ruby River below Ramshorn Creek, near Sheridan, Montana	839	R (MAJ–dam)	At-site	26	1947–53, 1997–2011, 2013–16	--	499	566	904	1,240	1,730	2,150	2,620	3,150	3,920
37B	06022000.11	Ruby River below Ramshorn Creek, near Sheridan, Montana	839	R (MAJ–dam)	MOVE.3	78	BP 1939–2016	Yes	522	592	956	1,320	1,880	2,360	2,900	3,520	4,450
38	06023000.10	Ruby River near Twin Bridges, Montana	970	R (MAJ–dam)	At-site	25	1942–43, 1947–65, 1980–81, 2015–16	--	648	710	987	1,220	1,520	1,750	1,980	2,210	2,520
38	06023000.11	Ruby River near Twin Bridges, Montana	970	R (MAJ–dam)	MOVE.3	78	BP 1939–2016	Yes	680	763	1,180	1,590	2,200	2,720	3,300	3,940	4,920
48	06026500.10	Jefferson River near Twin Bridges, Montana	7,616	R (MAJ–dam)	At-site	31	1965–72, 1994–2016	--	8,620	9,160	11,400	13,100	15,100	16,500	17,800	19,100	20,700
48	06026500.11	Jefferson River near Twin Bridges, Montana	7,616	R (MAJ–dam)	MOVE.3	52	BP 1965–2016	--	8,430	8,990	11,300	13,000	15,000	16,400	17,600	18,900	20,400
48	06026500.20	Jefferson River near Twin Bridges, Montana	7,616	Total	At-site	65	1911–16, 1921–39, 1942–43, 1958–72, 1994–2016	--	8,130	8,800	11,600	13,800	16,300	18,000	19,700	21,200	23,200
48	06026500.21	Jefferson River near Twin Bridges, Montana	7,616	Total	MOVE.3	111	BP 1895, 1897–1905, 1911–16, 1921–26, 1928–2016	--	8,260	8,880	11,500	13,400	15,700	17,300	18,800	20,200	22,000
64	06036650.10	Jefferson River near Three Forks, Montana	9,558	R (MAJ–dam)	At-site	44	1965–69, 1975, 1979–2016	Yes	8,220	8,960	12,200	14,900	18,200	20,700	23,200	25,600	28,900
64	06036650.11	Jefferson River near Three Forks, Montana	9,558	R (MAJ–dam)	MOVE.3	52	BP 1965–2016	--	9,300	9,950	12,700	14,900	17,500	19,400	21,300	23,100	25,400
64	06036650.20	Jefferson River near Three Forks, Montana	9,558	Total	At-site	80	1895, 1897–1905, 1939–69, 1975, 1979–2016	Yes	8,490	9,220	12,400	14,900	18,000	20,300	22,500	24,600	27,400
64	06036650.21	Jefferson River near Three Forks, Montana	9,558	Total	MOVE.3	111	BP 1895, 1897–1905, 1911–16, 1921–26, 1928–2016	--	9,040	9,750	12,700	15,000	17,800	19,800	21,700	23,600	26,000
69	06037500.00	Madison River near West Yellowstone, Montana	435	U	At-site	90	1914–17, 1919–73, 1984–86, 1989–2016	Yes	1,360	1,430	1,730	1,970	2,270	2,480	2,700	2,920	3,210
70	06038500.10	Madison River below Hebgen Lake, near Grayling, Montana	931	R (MAJ–dam)	At-site	56	1960–67, 1969–2016	--	2,300	2,430	2,980	3,420	3,980	4,400	4,830	5,260	5,840
72	06038800.10	Madison River at Kirby Ranch, near Cameron, Montana	1,092	R (MAJ–dam)	At-site	35	1960–61, 1963, 1985–2016	--	2,670	2,860	3,740	4,460	5,380	6,070	6,770	7,480	8,440
72	06038800.11	Madison River at Kirby Ranch, near Cameron, Montana	1,092	R (MAJ–dam)	MOVE.3	57	BP 1960–2016	--	2,820	3,020	3,870	4,550	5,410	6,040	6,660	7,290	8,120
73	06040000.10	Madison River near Cameron, Montana	1,665	R (MAJ–dam)	At-site	13	1960–63, 1968–70, 2011–16	--	4,290	4,650	6,200	7,460	9,010	10,100	11,300	12,400	13,800
73	06040000.11	Madison River near Cameron, Montana	1,665	R (MAJ–dam)	MOVE.3	57	BP 1960–2016	--	4,350	4,670	6,010	7,050	8,290	9,160	10,000	10,800	11,900
75	06041000.10	Madison River below Ennis Lake, near McAllister, Montana	2,150	R (MAJ–dam)	At-site	57	1960–2016	--	4,760	5,060	6,330	7,290	8,420	9,200	9,940	10,700	11,600
76	06042500.11	Madison River near Three Forks, Montana	2,453	R (MAJ–dam)	MOVE.3	57	BP 1960–2016	--	4,810	5,130	6,450	7,440	8,600	9,420	10,200	10,900	11,900

[1]The streamgage identification number and analysis designation is defined by XXXXXXXX.AB,
where,
XXXXXXXX is the streamgage identification number;
A is the regulation status for the analysis period; and
B is the type of peak-flow frequency analysis.

Values of A (regulation status) are defined as:
A = 0, unregulated;
A = 1, regulated by major regulation; and
A =2, total; that is, the combined unregulated and regulated peak-flow records for streamgages with peak-flow records before and after the start of regulation (see footnote 2).

Values of B (type of peak-flow frequency analysis) are defined as:
B = 0, at-site peak-flow frequency analysis conducted on recorded data;
B = 1, peak-flow frequency analysis conducted on combined recorded and synthesized data; synthesized data from Maintenance of Variance Extension Type III (MOVE.3) record extension procedure;
B =2, peak-flow frequency analysis determined from regional regression equations (RREs); RRE frequency results not presented in this report; and
B = 3, at-site peak-flow frequency analysis weighted with results from RREs; distributional parameters not available for RRE weighted frequency analyses.

06018500.10 Beaverhead River near Twin Bridges, Montana
Analysis for regulated period of record
Analysis period of record, water years: 1965–2016
At-site peak-flow frequency analysis conducted on recorded data

Table 1-1 Table 1-2 Table 1-3 Table 1-4 Table 1-5 Table 1-6 Table 1-7 Table 1-8

[Water year is the 12-month period from October 1 through September 30 and is designated by the year in which it ends. PILF; potentially influential low flow; MGBT, multiple Grubbs-Beck test]

Contributing drainage area, in square miles	Number of recorded peak flows used in the analysis	Skew type used in analysis	Type of PILF threshold[1]	PILF threshold, in cubic feet per second				Type of peak-flow frequency analysis
3,618	52	Weighted	MGBT	--				At-site
Peak flow, in cubic feet per second, for indicated annual exceedance probability (bold values), in percent								
50	**42.9**	**20**	**10**	**4**	**2**	**1.0**	**0.5**	**0.2**
696	760	1,050	1,300	1,620	1,870	2,120	2,380	2,730
Upper and lower 90-percent confidence intervals, in cubic feet per second, for indicated annual exceedance probability, in percent								
50	**42.9**	**20**	**10**	**4**	**2**	**1.0**	**0.5**	**0.2**
805	880	1,250	1,610	2,200	2,730	3,350	4,060	5,190
601	658	907	1,110	1,350	1,520	1,670	1,810	1,980

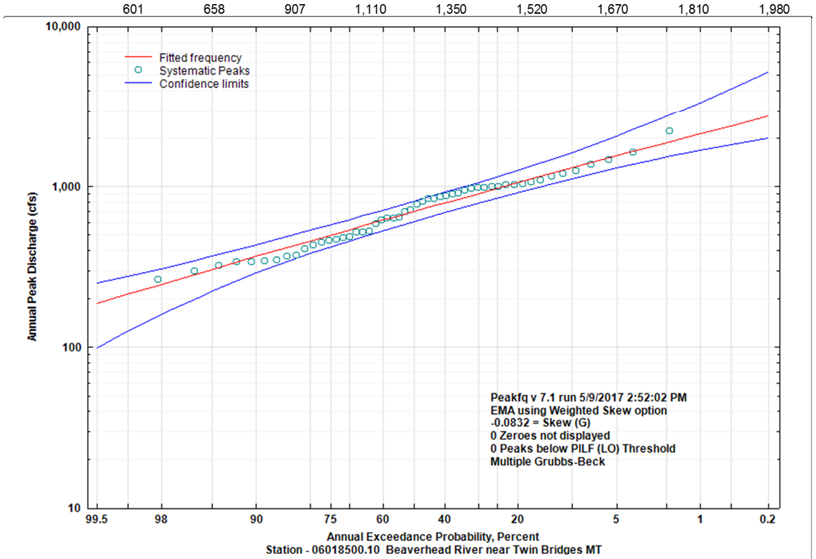

Figure 1. Annual peak flows (probability plotting positions) and peak-flow frequency curve.

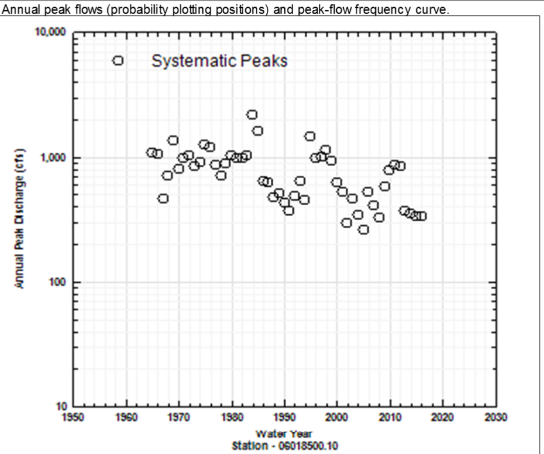

Figure 2. Annual peak flows and perception thresholds.

[1]Definitions of types of PILF thresholds include:
MGBT: PILF threshold calculated by using the multiple Grubbs-Beck Test as specifed in Bulletin 17C (England and others, 2016);
Manual: PILF threshold based on a systematic peak flow selected by the peak-flow frequency analyst.

[2]Peak-flow data with a value of zero are not plotted in figures 1 or 2.
[3]In cases where the month, day, or both are not present in the date of a peak flow (as indicated by adjacent slash marks with no intervening values), the month, day, or both are unknown.
[4]Definitions of peak-flow designations used in analysis include:
PT definition: The peak flow is used to define perception thresholds in ungaged historical periods;
Opportunistic: The peak flow was excluded from the analysis because it is outside of the systematic record and was of insufficient magnitude to determine nonexceedance during an ungaged period;
PILF: The peak flow was identified as a potentially influential low flow;
Synthesized: The peak flow was synthesized using Maintenance of Variance Extension Type III record extension.

England, J.F. Jr., Cohn, T.A., Faber, B.A., Stedinger, J.R., Thomas Jr., W.O., Veilleux, A.G., Kiang, J.E., and Mason, R.R., 2017, Guidelines for Determining Flood Flow Frequency – Bulletin 17C: U.S. Geological Survey Techniques and Methods book 4, chap. B5, 167 p., https://dx.doi.org/10.3133/tm4–B5/, accessed October 2, 2017 at https://acwi.gov/hydrology/Frequency/b17c/bulletin17c-draft-for-soh-31Aug2017.pdf.

06018500.10 Beaverhead River near Twin Bridges, Montana
Analysis for regulated period of record
Analysis period of record, water years: 1965–2016
At-site peak-flow frequency analysis conducted on recorded data

Table 1-1 Table 1-2 Table 1-3 Table 1-4 Table 1-5 Table 1-6 Table 1-7 Table 1-8

[Water year is the 12-month period from October 1 through September 30 and is designated by the year in which it ends.]

Peak-flow data[2]					Ranked (largest to smallest) peak-flow data[2]				
Water year	Date	Peak flow, in cubic feet per second	Gage height, in feet	Peak-flow designation in analysis[4]	Water year	Date	Peak flow, in cubic feet per second	Gage height, in feet	Peak-flow designation in analysis[4]
1965	09/29/1965	1,090	6.49		1984	06/25/1984	2,200	7.88	
1966	10/10/1965	1,060	6.44		1985	10/01/1984	1,620	7.31	
1967	06/24/1967	459	4.68		1995	07/14/1995	1,460	6.93	
1968	04/02/1968	712	5.43		1969	05/02/1969	1,370	6.78	
1969	05/02/1969	1,370	6.78		1975	08/01/1975	1,250	6.62	
1970	05/31/1970	807	5.75		1976	05/24/1976	1,200	6.252	
1971	07/05/1971	969	6.23		1998	06/29/1998	1,150	6.79	
1972	04/06/1972	1,040	6.182		1965	09/29/1965	1,090	6.49	
1973	11/12/1972	843	5.742		1966	10/10/1965	1,060	6.44	
1974	03/19/1974	910	5.60		1972	04/06/1972	1,040	6.182	
1975	08/01/1975	1,250	6.62		1980	06/08/1980	1,020	5.92	
1976	05/24/1976	1,200	6.252		1983	08/24/1983	1,020	6.21	
1977	10/26/1976	876	5.722		1997	04/24/1997	994	6.35	
1978	05/27/1978	700	5.13		1982	05/30/1982	991	5.80	
1979	04/25/1979	898	5.53		1981	05/22/1981	987	5.93	
1980	06/08/1980	1,020	5.92		1996	11/16/1995	983	6.51	
1981	05/22/1981	987	5.93		1971	07/05/1971	969	6.23	
1982	05/30/1982	991	5.80		1999	11/16/1998	940	6.31	
1983	08/24/1983	1,020	6.21		1974	03/19/1974	910	5.60	
1984	06/25/1984	2,200	7.88		1979	04/25/1979	898	5.53	
1985	10/01/1984	1,620	7.31		1977	10/26/1976	876	5.722	
1986	02/24/1986	640	5.60		2011	06/12/2011	863	6.22	
1987	07/19/1987	633	5.502		1973	11/12/1972	843	5.742	
1988	12/17/1987	480	5.022		2012	10/07/2011	840	6.30	
1989	03/10/1989	517	5.22		1970	05/31/1970	807	5.75	
1990	08/27/1990	430	4.962		2010	10/20/2009	776	6.112	
1991	12/13/1990	368	4.71		1968	04/02/1968	712	5.43	
1992	06/17/1992	486	5.24		1978	05/27/1978	700	5.13	
1993	07/27/1993	637	6.07		1986	02/24/1986	640	5.60	
1994	04/04/1994	450	5.10		1993	07/27/1993	637	6.07	
1995	07/14/1995	1,460	6.93		1987	07/19/1987	633	5.502	
1996	11/16/1995	983	6.51		2000	12/06/1999	620	5.41	
1997	04/24/1997	994	6.35		2009	06/22/2009	584	5.56	
1998	06/29/1998	1,150	6.79		2001	06/14/2001	529	5.31	
1999	11/16/1998	940	6.31		2006	04/07/2006	520	5.23	
2000	12/06/1999	620	5.41		1989	03/10/1989	517	5.22	
2001	06/14/2001	529	5.31		1992	06/17/1992	486	5.24	
2002	12/02/2001	297	4.38		1988	12/17/1987	480	5.022	
2003	03/15/2003	465	4.95		2003	03/15/2003	465	4.95	
2004	11/09/2003	344	4.61		1967	06/24/1967	459	4.68	
2005	02/17/2005	263	4.302		1994	04/04/1994	450	5.10	
2006	04/07/2006	520	5.23		1990	08/27/1990	430	4.962	
2007	03/14/2007	410	4.80		2007	03/14/2007	410	4.80	
2008	05/24/2008	323	4.54		2013	11/12/2012	373	4.74	
2009	06/22/2009	584	5.56		1991	12/13/1990	368	4.71	
2010	10/20/2009	776	6.112		2014	03/05/2014	349	4.562	
2011	06/12/2011	863	6.22		2004	11/09/2003	344	4.61	
2012	10/07/2011	840	6.30		2015	02/09/2015	339	4.522	
2013	11/12/2012	373	4.74		2016	11/22/2015	339	4.64	
2014	03/05/2014	349	4.562		2008	05/24/2008	323	4.54	
2015	02/09/2015	339	4.522		2002	12/02/2001	297	4.38	
2016	11/22/2015	339	4.64		2005	02/17/2005	263	4.302	

06019500.00 Ruby River above reservoir, near Alder, Montana
Analysis for unregulated period of record
Analysis period of record, water years: 1939–2016
At-site peak-flow frequency analysis conducted on recorded data

Table 1-1 Table 1-2 Table 1-3 Table 1-4 Table 1-5 Table 1-6 Table 1-7 Table 1-8

[Water year is the 12-month period from October 1 through September 30 and is designated by the year in which it ends. PILF; potentially influential low flow; MGBT, multiple Grubbs-Beck test]

Contributing drainage area, in square miles	Number of recorded peak flows used in the analysis	Skew type used in analysis	Type of PILF threshold[1]	PILF threshold, in cubic feet per second				Type of peak-flow frequency analysis
534	78	Station	MGBT	--				At-site
Peak flow, in cubic feet per second, for indicated annual exceedance probability (bold values), in percent								
50	**42.9**	**20**	**10**	**4**	**2**	**1.0**	**0.5**	**0.2**
938	1,000	1,300	1,580	1,990	2,330	2,700	3,120	3,730
Upper and lower 90-percent confidence intervals, in cubic feet per second, for indicated annual exceedance probability, in percent								
50	**42.9**	**20**	**10**	**4**	**2**	**1.0**	**0.5**	**0.2**
1,030	1,100	1,480	1,910	2,720	3,630	4,920	6,720	9,730
853	908	1,170	1,400	1,700	1,930	2,160	2,400	2,730

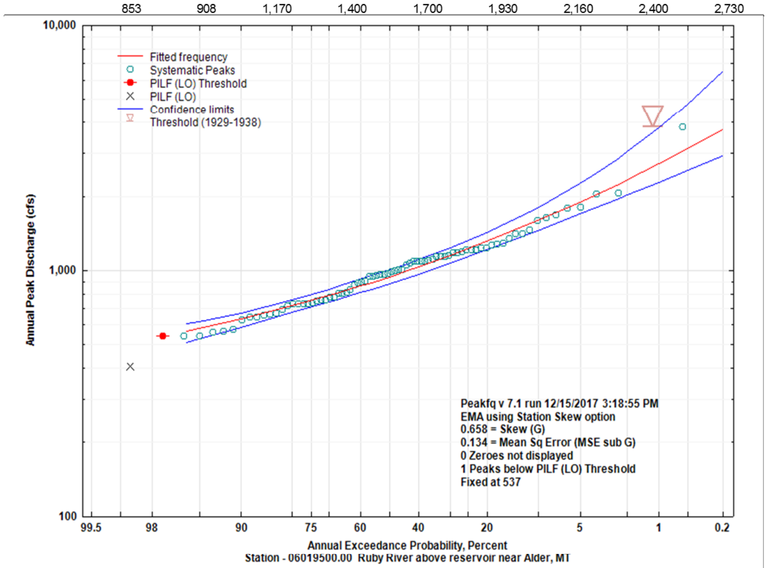

Figure 1. Annual peak flows (probability plotting positions) and peak-flow frequency curve.

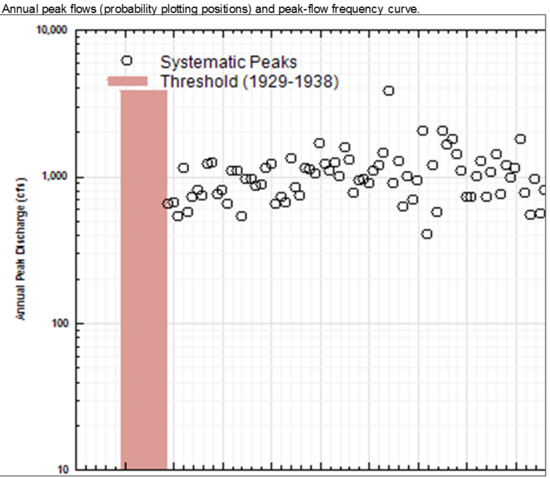

Figure 2. Annual peak flows and perception thresholds.

[1]Definitions of types of PILF thresholds include:
MGBT: PILF threshold calculated by using the multiple Grubbs-Beck Test as specifed in Bulletin 17C (England and others, 2016);
Manual: PILF threshold based on a systematic peak flow selected by the peak-flow frequency analyst.

[2]Peak-flow data with a value of zero are not plotted in figures 1 or 2.
[3]In cases where the month, day, or both are not present in the date of a peak flow (as indicated by adjacent slash marks with no intervening values), the month, day, or both are unknown.
[4]Definitions of peak-flow designations used in analysis include:
PT definition: The peak flow is used to define perception thresholds in ungaged historical periods;
Opportunistic: The peak flow was excluded from the analysis because it is outside of the systematic record and was of insufficient magnitude to determine nonexceedance during an ungaged period;
PILF: The peak flow was identified as a potentially influential low flow;
Synthesized: The peak flow was synthesized using Maintenance of Variance Extension Type III record extension.

England, J.F. Jr., Cohn, T.A., Faber, B.A., Stedinger, J.R., Thomas Jr., W.O., Veilleux, A.G., Kiang, J.E., and Mason, R.R., 2017, Guidelines for Determining Flood Flow Frequency – Bulletin 17C: U.S. Geological Survey Techniques and Methods book 4, chap. B5, 167 p., https://dx.doi.org/10.3133/tm4–B5/, accessed October 2, 2017 at https://acwi.gov/hydrology/Frequency/b17c/bulletin17c-draft-for-soh-31Aug2017.pdf.

06019500.00 Ruby River above reservoir, near Alder, Montana
Analysis for unregulated period of record
Analysis period of record, water years: 1939–2016
At-site peak-flow frequency analysis conducted on recorded data

Table 1-1 Table 1-2 Table 1-3 Table 1-4 Table 1-6 Table 1-7 Table 1-8 Table 1-8'!A6

[Water year is the 12-month period from October 1 through September 30 and is designated by the year in which it ends.]

Peak-flow data[2]					Ranked (largest to smallest) peak-flow data[2]				
Water year	Date[3]	Peak flow, in cubic feet per second	Gage height, in feet	Peak-flow designation in analysis[4]	Water year	Date[3]	Peak flow, in cubic feet per second	Gage height, in feet	Peak-flow designation in analysis[4]
1939	05/05/1939	645	--		1984	05/16/1984	3,810	6.24	PT definition
1940	05/13/1940	668	--		1995	06/06/1995	2,060	5.14	
1941	05/27/1941	537	--		1991	08/26/1991	2,040	5.52	
1942	05/27/1942	1,140	--		1997	06/02/1997	1,800	5.12	
1943	05/30/1943	575	--		2011	06/08/2011	1,780	6.07	
1944	06/09/1944	730	--		1970	06/10/1970	1,670	5.62	
1945	08/03/1945	805	--		1996	06/10/1996	1,630	4.89	
1946	06/06/1946	735	--		1975	06/25/1975	1,590	5.41	
1947	06/10/1947	1,210	--		1983	06/12/1983	1,460	5.30	
1948	05/21/1948	1,230	--		2006	05/21/2006	1,410	6.13	
1949	05/17/1949	755	--		1998	06/27/1998	1,400	5.96	
1950	06/07/1950	800	--		1964	06/08/1964	1,340	5.43	
1951	05/24/1951	654	--		1976	05/19/1976	1,290	4.80	
1952	05/04/1952	1,090	--		1986	05/29/1986	1,270	4.95	
1953	06/14/1953	1,090	--		2003	05/31/2003	1,260	5.55	
1954	05/22/1954	539	--		1948	05/21/1948	1,230	--	
1955	06/16/1955	950	--		1973	05/21/1973	1,230	5.01	
1956	05/28/1956	960	4.70		1947	06/10/1947	1,210	--	
1957	06/03/1957	867	4.47		1960	05/13/1960	1,210	5.20	
1958	05/24/1958	885	4.55		1971	05/29/1971	1,210	5.01	
1959	06/07/1959	1,140	5.05		2008	05/21/2008	1,190	5.58	
1960	05/13/1960	1,210	5.20		1982	06/17/1982	1,180	4.77	
1961	05/27/1961	644	4.05		1993	05/21/1993	1,180	4.68	
1962	06/04/1962	729	4.22		2010	06/05/2010	1,150	5.49	
1963	05/25/1963	662	4.07		1942	05/27/1942	1,140	--	
1964	06/08/1964	1,340	5.43		1959	06/07/1959	1,140	5.05	
1965	06/13/1965	835	4.48		1967	06/22/1967	1,140	5.05	
1966	05/11/1966	747	4.26		1968	06/04/1968	1,110	4.98	
1967	06/22/1967	1,140	5.05		1981	05/31/1981	1,100	4.64	
1968	06/04/1968	1,110	4.98		1952	05/04/1952	1,090	--	
1969	05/27/1969	1,050	4.82		1953	06/14/1953	1,090	--	
1970	06/10/1970	1,670	5.62		1972	06/08/1972	1,090	4.89	
1971	05/29/1971	1,210	5.01		1999	06/17/1999	1,090	5.36	
1972	06/08/1972	1,090	4.89		2005	05/17/2005	1,070	5.15	
1973	05/21/1973	1,230	5.01		1969	05/27/1969	1,050	4.82	
1974	06/17/1974	1,000	4.72		1974	06/17/1974	1,000	4.72	
1975	06/25/1975	1,590	5.41		1988	05/17/1988	1,000	4.53	
1976	05/19/1976	1,290	4.80		2002	06/03/2002	998	5.15	
1977	06/12/1977	776	4.03		2009	05/20/2009	989	5.15	
1978	05/16/1978	942	4.34		1979	05/28/1979	969	4.39	
1979	05/28/1979	969	4.39		1956	05/28/1956	960	4.70	
1980	05/09/1980	893	4.18		2014	05/14/2014	959	5.04	
1981	05/31/1981	1,100	4.64		1955	06/16/1955	950	--	
1982	06/17/1982	1,180	4.77		1978	05/16/1978	942	4.34	
1983	06/12/1983	1,460	5.30		1990	06/11/1990	939	4.43	
1984	05/16/1984	3,810	6.24	PT definition	1985	05/04/1985	904	4.47	
1985	05/04/1985	904	4.47		1980	05/09/1980	893	4.18	
1986	05/29/1986	1,270	4.95		1958	05/24/1958	885	4.55	
1987	05/17/1987	629	3.87		1957	06/03/1957	867	4.47	
1988	05/17/1988	1,000	4.53		1965	06/13/1965	835	4.48	
1989	05/11/1989	694	4.06		2016	05/21/2016	811	4.66	
1990	06/11/1990	939	4.43		1945	08/03/1945	805	--	
1991	08/26/1991	2,040	5.52		1950	06/07/1950	800	--	
1992	05/09/1992	406	3.40	PILF	2012	04/27/2012	778	4.76	
1993	05/21/1993	1,180	4.68		1977	06/12/1977	776	4.03	
1994	05/09/1994	566	3.76		1949	05/17/1949	755	--	
1995	06/06/1995	2,060	5.14		2007	03/13/2007	754	4.57	
1996	06/10/1996	1,630	4.89		1966	05/11/1966	747	4.26	
1997	06/02/1997	1,800	5.12		1946	06/06/1946	735	--	
1998	06/27/1998	1,400	5.96		2004	06/11/2004	731	4.39	
1999	06/17/1999	1,090	5.36		1944	06/09/1944	730	--	
2000	05/26/2000	727	4.50		1962	06/04/1962	729	4.22	
2001	05/14/2001	719	4.48		2000	05/26/2000	727	4.50	
2002	06/03/2002	998	5.15		2001	05/14/2001	719	4.48	
2003	05/31/2003	1,260	5.55		1989	05/11/1989	694	4.06	
2004	06/11/2004	731	4.39		1940	05/13/1940	668	--	
2005	05/17/2005	1,070	5.15		1963	05/25/1963	662	4.07	
2006	05/21/2006	1,410	6.13		1951	05/24/1951	654	--	
2007	03/13/2007	754	4.57		1939	05/05/1939	645	--	
2008	05/21/2008	1,190	5.58		1961	05/27/1961	644	4.05	
2009	05/20/2009	989	5.15		1987	05/17/1987	629	3.87	
2010	06/05/2010	1,150	5.49		1943	05/30/1943	575	--	
2011	06/08/2011	1,780	6.07		1994	05/09/1994	566	3.76	
2012	04/27/2012	778	4.76		2015	06/01/2015	560	4.22	
2013	05/14/2013	541	4.17		2013	05/14/2013	541	4.17	
2014	05/14/2014	959	5.04		1954	05/22/1954	539	--	
2015	06/01/2015	560	4.22		1941	05/27/1941	537	--	
2016	05/21/2016	811	4.66		1992	05/09/1992	406	3.40	PILF

06020600.11 Ruby River below reservoir, near Alder, Montana
Analysis for regulated period of record
Analysis period of record, water years: 1939–2016
Peak-flow frequency analysis conducted on recorded and synthesized data

Table 1-1 Table 1-2 Table 1-3 Table 1-4 Table 1-5 Table 1-6 Table 1-7 Table 1-8

[Water year is the 12-month period from October 1 through September 30 and is designated by the year in which it ends. PILF; potentially influential low flow; MGBT, multiple Grubbs-Beck test]

Contributing drainage area, in square miles								Type of peak-flow frequency analysis
595								MOVE.3
Peak flow, in cubic feet per second, for indicated annual exceedance probability (bold values), in percent								
50	**42.9**	**20**	**10**	**4**	**2**	**1.0**	**0.5**	**0.2**
849	914	1,210	1,470	1,820	2,100	2,390	2,700	3,130
Upper and lower 90-percent confidence intervals, in cubic feet per second, for indicated annual exceedance probability, in percent								
50	**42.9**	**20**	**10**	**4**	**2**	**1.0**	**0.5**	**0.2**
955	1,030	1,400	1,780	2,440	3,060	3,840	4,800	6,380
754	810	1,070	1,270	1,520	1,710	1,880	2,040	2,250

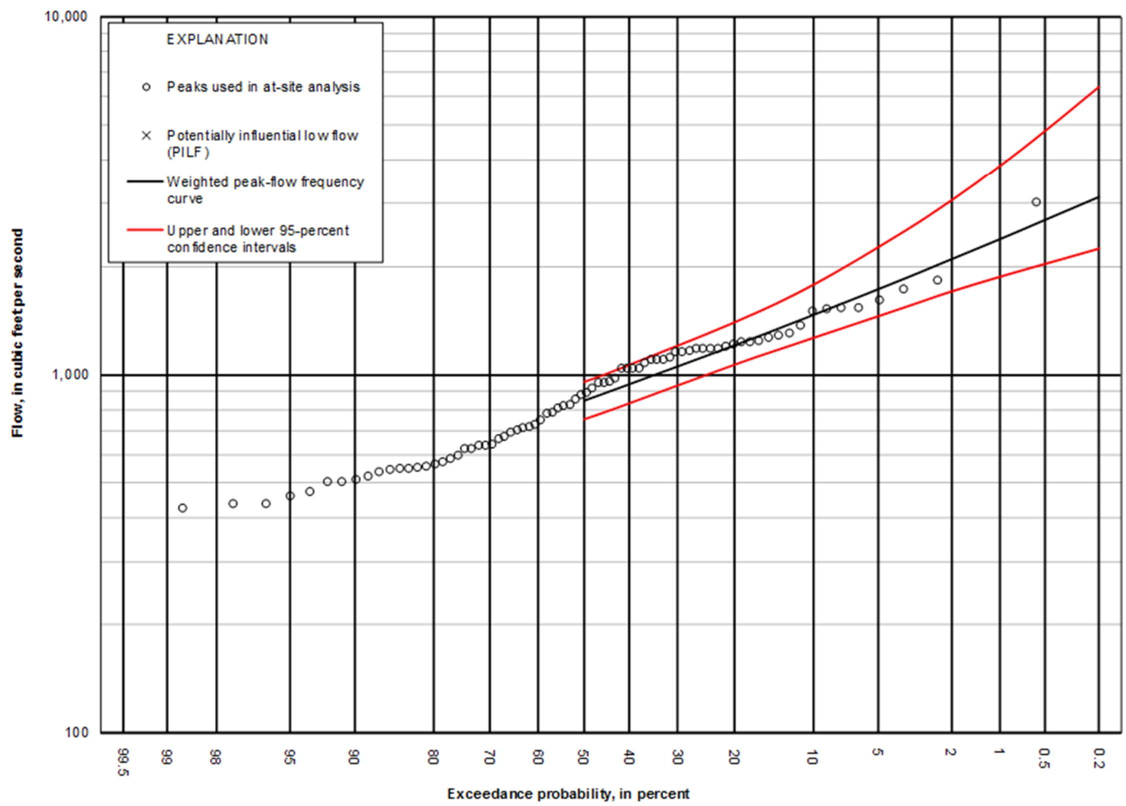

Figure 1. Annual peak flows (plotting positions determined using the Cunnane formulation; Helsel and Hirsch, 2002) and peak-flow frequency curve

[1]Peak flows with a value of zero are not plotted in figure 1 .
[2]In cases where the month, day, or both are not present in the date of a peak flow (as indicated by adjacent slash marks with no intervening values), the month, day, or both are unknown.
[3]Flood-frequency results not reported because of too many values less than the PILF threshold used in the at-site analysis.
[4]Definitions of peak-flow designations used in analysis include:
PT definition: The peak flow is used to define perception thresholds in ungaged historical periods;
Opportunistic: The peak flow was excluded from the analysis because it is outside of the systematic record and was of insufficient magnitude to determine nonexceedance during an ungaged period;
PILF: The peak flow was identified as a potentially influential low flow;

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06020600.11 Ruby River below reservoir, near Alder, Montana
Analysis for regulated period of record
Analysis period of record, water years: 1939–2016
Peak-flow frequency analysis conducted on recorded and synthesized data

Table 1-1 Table 1-2 Table 1-3 Table 1-4 Table 1-5 Table 1-6 Table 1-7 Table 1-8

[Water year is the 12-month period from October 1 through September 30 and is designated by the year in which it ends.]

Peak-flow data[2]					Ranked (largest to smallest) peak-flow data[2]				
Water year	Date[3]	Peak flow, in cubic feet per second	Gage height, in feet	Peak-flow designation in analysis[4]	Water year	Date[3]	Peak flow, in cubic feet per second	Gage height, in feet	Peak-flow designation in analysis[4]
1939	//1939	544	--	Synthesized	1984	05/16/1984	3,010	8.52	PT definition
1940	//1940	568	--	Synthesized	1995	06/07/1995	1,820	6.85	
1941	//1941	434	--	Synthesized	2011	06/09/2011	1,720	6.31	
1942	//1942	1,100	--	Synthesized	1970	06/10/1970	1,610	5.37	
1943	//1943	472	--	Synthesized	1964	06/09/1964	1,530	4.66	
1944	//1944	634	--	Synthesized	1973	05/21/1973	1,530	--	
1945	//1945	715	--	Synthesized	1975	06/26/1975	1,520	5.15	
1946	//1946	639	--	Synthesized	1983	06/12/1983	1,500	5.19	
1947	//1947	1,180	--	Synthesized	1998	06/27/1998	1,360	6.11	
1948	//1948	1,210	--	Synthesized	1997	06/03/1997	1,300	5.94	
1949	//1949	661	--	Synthesized	1991	06/06/1991	1,280	5.90	
1950	//1950	709	--	Synthesized	1972	06/09/1972	1,260	4.09	
1951	//1951	553	--	Synthesized	1993	05/23/1993	1,240	5.85	
1952	//1952	1,040	--	Synthesized	1971	06/28/1971	1,230	3.98	
1953	//1953	1,040	--	Synthesized	1996	06/10/1996	1,230	5.79	
1954	//1954	436	--	Synthesized	1948	//1948	1,210	--	Synthesized
1955	//1955	877	--	Synthesized	1976	05/19/1976	1,190	4.34	
1956	//1956	888	--	Synthesized	1947	//1947	1,180	--	Synthesized
1957	//1957	783	--	Synthesized	1960	//1960	1,180	--	Synthesized
1958	//1958	804	--	Synthesized	1981	05/31/1981	1,180	4.15	
1959	//1959	1,100	--	Synthesized	1982	06/19/1982	1,180	4.39	
1960	//1960	1,180	--	Synthesized	1974	06/17/1974	1,160	4.19	
1961	//1961	543	--	Synthesized	1968	06/05/1968	1,150	3.91	
1962	//1962	633	--	Synthesized	1986	05/31/1986	1,150	5.72	
1963	06/05/1963	594	2.49		1969	05/16/1969	1,110	--	
1964	06/09/1964	1,530	4.66		1942	//1942	1,100	--	Synthesized
1965	06/13/1965	814	3.21		1959	//1959	1,100	--	Synthesized
1966	05/11/1966	691	2.93		2003	05/31/2003	1,100	5.46	
1967	06/02/1967	852	3.23		2010	06/05/2010	1,070	5.36	
1968	06/05/1968	1,150	3.91		1952	//1952	1,040	--	Synthesized
1969	05/16/1969	1,110	--		1953	//1953	1,040	--	Synthesized
1970	06/10/1970	1,610	5.37		1999	05/30/1999	1,040	5.34	
1971	06/28/1971	1,230	3.98		2008	05/22/2008	1,040	5.40	
1972	06/09/1972	1,260	4.09		2006	05/21/2006	975	5.25	
1973	05/21/1973	1,530	--		2014	05/29/2014	953	5.04	
1974	06/17/1974	1,160	4.19		1978	06/10/1978	948	3.80	
1975	06/26/1975	1,520	5.15		1980	06/12/1980	944	3.84	
1976	05/19/1976	1,190	4.34		1979	05/28/1979	910	3.70	
1977	06/12/1977	583	3.03		1956	//1956	888	--	Synthesized
1978	06/10/1978	948	3.80		1955	//1955	877	--	Synthesized
1979	05/28/1979	910	3.70		1967	06/02/1967	852	3.23	
1980	06/12/1980	944	3.84		2005	05/21/2005	822	4.90	
1981	05/31/1981	1,180	4.15		1965	06/13/1965	814	3.21	
1982	06/19/1982	1,180	4.39		1958	//1958	804	--	Synthesized
1983	06/12/1983	1,500	5.19		1957	//1957	783	--	Synthesized
1984	05/16/1984	3,010	8.52	PT definition	1988	05/17/1988	778	4.81	
1985	05/23/1985	545	4.35		1987	05/13/1987	744	4.75	
1986	05/31/1986	1,150	5.72		2016	05/22/2016	722	4.65	
1987	05/13/1987	744	4.75		1945	//1945	715	--	Synthesized
1988	05/17/1988	778	4.81		1950	//1950	709	--	Synthesized
1989	06/08/1989	500	4.03		2009	05/30/2009	696	4.60	
1990	05/14/1990	507	4.05		1966	05/11/1966	691	2.93	
1991	06/06/1991	1,280	5.90		2012	04/27/2012	671	4.47	
1992	05/14/1992	536	4.16		1949	//1949	661	--	Synthesized
1993	05/23/1993	1,240	5.85		1946	//1946	639	--	Synthesized
1994	05/20/1994	561	4.28		1944	//1944	634	--	Synthesized
1995	06/07/1995	1,820	6.85		1962	//1962	633	--	Synthesized
1996	06/10/1996	1,230	5.79		2001	05/14/2001	619	4.39	
1997	06/03/1997	1,300	5.94		2007	05/13/2007	619	4.39	
1998	06/27/1998	1,360	6.11		1963	06/05/1963	594	2.49	
1999	05/30/1999	1,040	5.34		1977	06/12/1977	583	3.03	
2000	05/27/2000	550	4.20		1940	//1940	568	--	Synthesized
2001	05/14/2001	619	4.39		1994	05/20/1994	561	4.28	
2002	05/21/2002	458	--		1951	//1951	553	--	Synthesized
2003	05/31/2003	1,100	5.46		2000	05/27/2000	550	4.20	
2004	05/12/2004	519	4.06		1985	05/23/1985	545	4.35	
2005	05/21/2005	822	4.90		1939	//1939	544	--	Synthesized
2006	05/21/2006	975	5.25		1961	//1961	543	--	Synthesized
2007	05/13/2007	619	4.39		1992	05/14/1992	536	4.16	
2008	05/22/2008	1,040	5.40		2004	05/12/2004	519	4.06	
2009	05/30/2009	696	4.60		1990	05/14/1990	507	4.05	
2010	06/05/2010	1,070	5.36		2013	05/11/2013	503	3.97	
2011	06/09/2011	1,720	6.31		1989	06/08/1989	500	4.03	
2012	04/27/2012	671	4.47		1943	//1943	472	--	Synthesized
2013	05/11/2013	503	3.97		2002	05/21/2002	458	--	
2014	05/29/2014	953	5.04		1954	//1954	436	--	Synthesized
2015	06/03/2015	423	3.82		1941	//1941	434	--	Synthesized
2016	05/22/2016	722	4.65		2015	06/03/2015	423	3.82	

06021500.11 Ruby River at Laurin, Montana
Analysis for regulated period of record
Analysis period of record, water years: 1939–2016
Peak-flow frequency analysis conducted on recorded and synthesized data

Table 1-1 Table 1-2 Table 1-3 Table 1-4 Table 1-5 Table 1-6 Table 1-7 Table 1-8

[Water year is the 12-month period from October 1 through September 30 and is designated by the year in which it ends. PILF; potentially influential low flow; MGBT, multiple Grubbs-Beck test]

Contributing drainage area, in square miles									Type of peak-flow frequency analysis
643									MOVE.3
Peak flow, in cubic feet per second, for indicated annual exceedance probability (bold values), in percent									
	50	**42.9**	**20**	**10**	**4**	**2**	**1.0**	**0.5**	**0.2**
	376	434	746	1,080	1,610	2,100	2,670	3,340	4,400
Upper and lower 90-percent confidence intervals, in cubic feet per second, for indicated annual exceedance probability, in percent									
	50	**42.9**	**20**	**10**	**4**	**2**	**1.0**	**0.5**	**0.2**
	546	636	1,160	1,890	3,550	5,630	8,730	13,300	22,700
	236	272	453	610	781	866	905	873	678

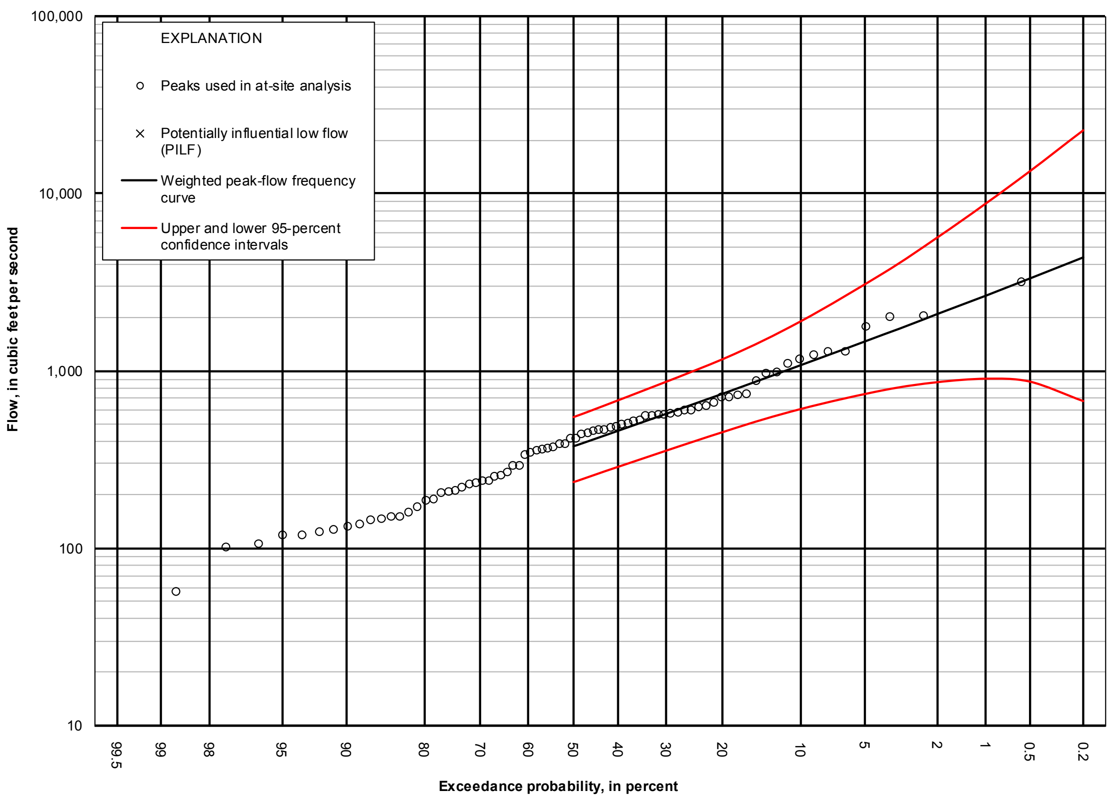

Figure 1. Annual peak flows (plotting positions determined using the Cunnane formulation; Helsel and HIrsch, 2002) and peak-flow frequency curve

[1]Peak flows with a value of zero are not plotted in figure 1 .

[2]In cases where the month, day, or both are not present in the date of a peak flow (as indicated by adjacent slash marks with no intervening values), the month, day, or both are unknown.

[3]Flood-frequency results not reported because of too many values less than the PILF threshold used in the at-site analysis.

[4]Definitions of peak-flow designations used in analysis include:

PT definition: The peak flow is used to define perception thresholds in ungaged historical periods;

Opportunistic: The peak flow was excluded from the analysis because it is outside of the systematic record and was of insufficient magnitude to determine nonexceedance during an ungaged period;

PILF: The peak flow was identified as a potentially influential low flow;

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06021500.11 Ruby River at Laurin, Montana
Analysis for regulated period of record
Analysis period of record, water years: 1939–2016
Peak-flow frequency analysis conducted on recorded and synthesized data

Table 1-1 Table 1-2 Table 1-3 Table 1-4 Table 1-5 Table 1-6 Table 1-7 Table 1-8

[Water year is the 12-month period from October 1 through September 30 and is designated by the year in which it ends.]

Peak-flow data[2]					Ranked (largest to smallest) peak-flow data[2]				
Water year	Date[3]	Peak flow, in cubic feet per second	Gage height, in feet	Peak-flow designation in analysis[4]	Water year	Date[3]	Peak flow, in cubic feet per second	Gage height, in feet	Peak-flow designation in analysis[4]
1939	//1939	157	--	Synthesized	1984	//1984	3,140	--	PT definition
1940	//1940	170	--	Synthesized	1995	//1995	2,040	--	Synthesized
1941	//1941	105	--	Synthesized	1991	//1991	2,000	--	Synthesized
1942	//1942	553	--	Synthesized	2011	//2011	1,750	--	Synthesized
1943	//1943	122	--	Synthesized	1970	//1970	1,280	--	Synthesized
1944	//1944	207	--	Synthesized	2010	//2010	1,280	--	Synthesized
1945	//1945	256	--	Synthesized	1996	//1996	1,220	--	Synthesized
1946	//1946	210	--	Synthesized	1975	//1975	1,150	--	Synthesized
1947	06/11/1947	980	6.43		2005	//2005	1,090	--	Synthesized
1948	06/05/1948	737	5.64		1947	06/11/1947	980	6.43	
1949	04/12/1949	230	2.00		1983	//1983	954	--	Synthesized
1950	06/25/1950	442	4.57		1964	//1964	875	--	Synthesized
1951	11/12/1950	143	2.00		1948	06/05/1948	737	5.64	
1952	05/09/1952	382	4.38		1976	//1976	726	--	Synthesized
1953	06/16/1953	568	5.05		2006	//2006	706	--	Synthesized
1954	07/20/1954	117	3.27		1986	//1986	702	--	Synthesized
1955	06/17/1955	473	4.67		1973	//1973	654	--	Synthesized
1956	05/29/1956	250	2.00		1971	//1971	630	--	Synthesized
1957	05/21/1957	352	4.51		1981	//1981	619	--	Synthesized
1958	11/20/1957	227	2.00		1982	//1982	596	--	Synthesized
1959	06/15/1959	367	4.32		1993	//1993	596	--	Synthesized
1960	05/14/1960	564	5.17		1963	//1963	579	--	Synthesized
1961	//1961	132	--	Synthesized	1953	06/16/1953	568	5.05	
1962	//1962	464	--	Synthesized	1960	05/14/1960	564	5.17	
1963	//1963	579	--	Synthesized	1965	//1965	560	--	Synthesized
1964	//1964	875	--	Synthesized	1942	//1942	553	--	Synthesized
1965	//1965	560	--	Synthesized	1967	//1967	553	--	Synthesized
1966	//1966	217	--	Synthesized	1968	//1968	521	--	Synthesized
1967	//1967	553	--	Synthesized	1998	//1998	513	--	Synthesized
1968	//1968	521	--	Synthesized	1972	//1972	501	--	Synthesized
1969	//1969	461	--	Synthesized	1997	//1997	496	--	Synthesized
1970	//1970	1,280	--	Synthesized	2008	//2008	482	--	Synthesized
1971	//1971	630	--	Synthesized	1955	06/17/1955	473	4.67	
1972	//1972	501	--	Synthesized	1962	//1962	464	--	Synthesized
1973	//1973	654	--	Synthesized	1969	//1969	461	--	Synthesized
1974	//1974	414	--	Synthesized	1980	//1980	455	--	Synthesized
1975	//1975	1,150	--	Synthesized	1950	06/25/1950	442	4.57	
1976	//1976	726	--	Synthesized	2014	//2014	435	--	Synthesized
1977	//1977	236	--	Synthesized	1974	//1974	414	--	Synthesized
1978	//1978	363	--	Synthesized	1988	//1988	414	--	Synthesized
1979	//1979	386	--	Synthesized	1979	//1979	386	--	Synthesized
1980	//1980	455	--	Synthesized	1952	05/09/1952	382	4.38	
1981	//1981	619	--	Synthesized	1959	06/15/1959	367	4.32	
1982	//1982	596	--	Synthesized	1978	//1978	363	--	Synthesized
1983	//1983	954	--	Synthesized	1990	//1990	360	--	Synthesized
1984	//1984	3,140	--	PT definition	1957	05/21/1957	352	4.51	
1985	//1985	331	--	Synthesized	2016	//2016	344	--	Synthesized
1986	//1986	702	--	Synthesized	1985	//1985	331	--	Synthesized
1987	//1987	149	--	Synthesized	1999	//1999	291	--	Synthesized
1988	//1988	414	--	Synthesized	2009	//2009	291	--	Synthesized
1989	//1989	185	--	Synthesized	2007	//2007	267	--	Synthesized
1990	//1990	360	--	Synthesized	1945	//1945	256	--	Synthesized
1991	//1991	2,000	--	Synthesized	1956	05/29/1956	250	2.00	
1992	//1992	56.6	--	Synthesized	2012	//2012	238	--	Synthesized
1993	//1993	596	--	Synthesized	1977	//1977	236	--	Synthesized
1994	//1994	118	--	Synthesized	1949	04/12/1949	230	2.00	
1995	//1995	2,040	--	Synthesized	1958	11/20/1957	227	2.00	
1996	//1996	1,220	--	Synthesized	1966	//1966	217	--	Synthesized
1997	//1997	496	--	Synthesized	1946	//1946	210	--	Synthesized
1998	//1998	513	--	Synthesized	1944	//1944	207	--	Synthesized
1999	//1999	291	--	Synthesized	2003	//2003	204	--	Synthesized
2000	//2000	144	--	Synthesized	2015	//2015	188	--	Synthesized
2001	//2001	136	--	Synthesized	1989	//1989	185	--	Synthesized
2002	//2002	126	--	Synthesized	1940	//1940	170	--	Synthesized
2003	//2003	204	--	Synthesized	1939	//1939	157	--	Synthesized
2004	//2004	150	--	Synthesized	2004	//2004	150	--	Synthesized
2005	//2005	1,090	--	Synthesized	1987	//1987	149	--	Synthesized
2006	//2006	706	--	Synthesized	2000	//2000	144	--	Synthesized
2007	//2007	267	--	Synthesized	1951	11/12/1950	143	2.00	
2008	//2008	482	--	Synthesized	2001	//2001	136	--	Synthesized
2009	//2009	291	--	Synthesized	1961	//1961	132	--	Synthesized
2010	//2010	1,280	--	Synthesized	2002	//2002	126	--	Synthesized
2011	//2011	1,750	--	Synthesized	1943	//1943	122	--	Synthesized
2012	//2012	238	--	Synthesized	1994	//1994	118	--	Synthesized
2013	//2013	101	--	Synthesized	1954	07/20/1954	117	3.27	
2014	//2014	435	--	Synthesized	1941	//1941	105	--	Synthesized
2015	//2015	188	--	Synthesized	2013	//2013	101	--	Synthesized
2016	//2016	344	--	Synthesized	1992	//1992	56.6	--	Synthesized

06022000.11 Ruby River below Ramshorn Creek, near Sheridan, Montana
Analysis for regulated period of record
Analysis period of record, water years: 1939–2016
Peak-flow frequency analysis conducted on recorded and synthesized data

Table 1-1 Table 1-2 Table 1-3 Table 1-4 Table 1-5 Table 1-6 Table 1-7 Table 1-8

[Water year is the 12-month period from October 1 through September 30 and is designated by the year in which it ends. PILF; potentially influential low flow; MGBT, multiple Grubbs-Beck test]

Contributing drainage area, in square miles								Type of peak-flow frequency analysis
839								MOVE.3
Peak flow, in cubic feet per second, for indicated annual exceedance probability (bold values), in percent								
50	**42.9**	**20**	**10**	**4**	**2**	**1.0**	**0.5**	**0.2**
522	592	956	1,320	1,880	2,360	2,900	3,520	4,450
Upper and lower 90-percent confidence intervals, in cubic feet per second, for indicated annual exceedance probability, in percent								
50	**42.9**	**20**	**10**	**4**	**2**	**1.0**	**0.5**	**0.2**
703	803	1,370	2,070	3,450	4,990	7,090	9,960	15,200
369	420	663	872	1,120	1,300	1,420	1,510	1,540

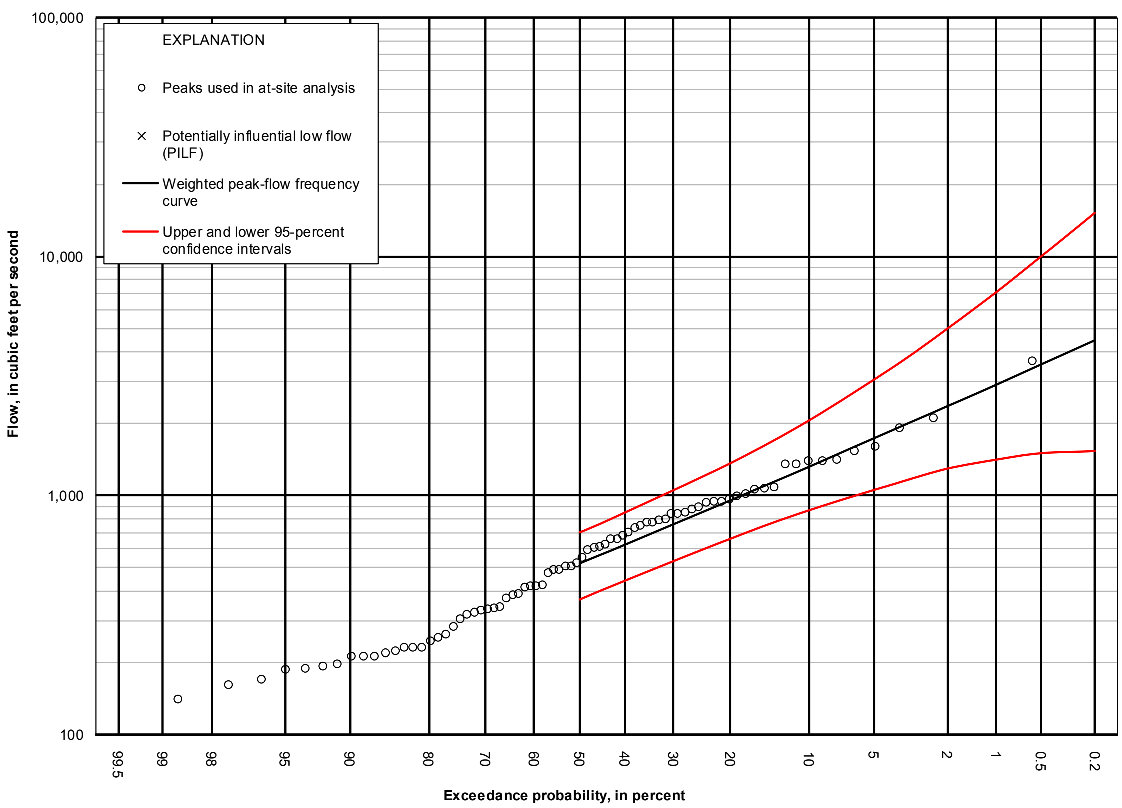

Figure 1. Annual peak flows (plotting positions determined using the Cunnane formulation; Helsel and HIrsch, 2002) and peak-flow frequency curve

[1]Peak flows with a value of zero are not plotted in figure 1 .
[2]In cases where the month, day, or both are not present in the date of a peak flow (as indicated by adjacent slash marks with no intervening values), the month, day, or both are unknown.
[3]Flood-frequency results not reported because of too many values less than the PILF threshold used in the at-site analysis.
[4]Definitions of peak-flow designations used in analysis include:
PT definition: The peak flow is used to define perception thresholds in ungaged historical periods;
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06022000.11 Ruby River below Ramshorn Creek, near Sheridan, Montana
Analysis for regulated period of record
Analysis period of record, water years: 1939–2016
Peak-flow frequency analysis conducted on recorded and synthesized data

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[Water year is the 12-month period from October 1 through September 30 and is designated by the year in which it ends.]

Peak-flow data[2]					Ranked (largest to smallest) peak-flow data[2]				
Water year	Date[3]	Peak flow, in cubic feet per second	Gage height, in feet	Peak-flow designation in analysis[4]	Water year	Date[3]	Peak flow, in cubic feet per second	Gage height, in feet	Peak-flow designation in analysis[4]
1939	//1939	230	--	Synthesized	1984	//1984	3,630	--	PT definition
1940	//1940	253	--	Synthesized	2011	06/10/2011	2,090	--	
1941	//1941	140	--	Synthesized	1995	//1995	1,910	--	Synthesized
1942	//1942	1,080	--	Synthesized	2010	06/19/2010	1,590	--	
1943	//1943	169	--	Synthesized	1970	//1970	1,530	--	Synthesized
1944	//1944	322	--	Synthesized	1973	//1973	1,400	--	Synthesized
1945	//1945	419	--	Synthesized	1975	//1975	1,380	--	Synthesized
1946	//1946	328	--	Synthesized	2005	06/19/2005	1,380	--	
1947	06/11/1947	1,340	6.32		1983	//1983	1,350	--	Synthesized
1948	06/04/1948	1,050	5.62		1947	06/11/1947	1,340	6.32	
1949	10/30/1948	338	3.25		1942	//1942	1,080	--	Synthesized
1950	06/25/1950	501	4.07		1964	//1964	1,060	--	Synthesized
1951	08/28/1951	262	2.89		1948	06/04/1948	1,050	5.62	
1952	06/07/1952	472	3.96		1991	//1991	1,010	--	Synthesized
1953	06/16/1953	763	4.88		1972	//1972	984	--	Synthesized
1954	//1954	185	--	Synthesized	1993	//1993	956	--	Synthesized
1955	//1955	656	--	Synthesized	1971	//1971	942	--	Synthesized
1956	//1956	368	--	Synthesized	1996	//1996	942	--	Synthesized
1957	//1957	502	--	Synthesized	2006	06/14/2006	927	--	
1958	//1958	337	--	Synthesized	1976	//1976	888	--	Synthesized
1959	//1959	521	--	Synthesized	1982	//1982	874	--	Synthesized
1960	//1960	769	--	Synthesized	1974	//1974	848	--	Synthesized
1961	//1961	211	--	Synthesized	1968	//1968	835	--	Synthesized
1962	//1962	618	--	Synthesized	1986	//1986	835	--	Synthesized
1963	//1963	747	--	Synthesized	1981	//1981	790	--	Synthesized
1964	//1964	1,060	--	Synthesized	1969	//1969	783	--	Synthesized
1965	//1965	725	--	Synthesized	1960	//1960	769	--	Synthesized
1966	//1966	334	--	Synthesized	1953	06/16/1953	763	4.88	
1967	//1967	487	--	Synthesized	1963	//1963	747	--	Synthesized
1968	//1968	835	--	Synthesized	1965	//1965	725	--	Synthesized
1969	//1969	783	--	Synthesized	1998	06/28/1998	695	--	
1970	//1970	1,530	--	Synthesized	1997	06/04/1997	674	--	
1971	//1971	942	--	Synthesized	2008	06/20/2008	657	--	
1972	//1972	984	--	Synthesized	1955	//1955	656	--	Synthesized
1973	//1973	1,400	--	Synthesized	1962	//1962	618	--	Synthesized
1974	//1974	848	--	Synthesized	1980	//1980	607	--	Synthesized
1975	//1975	1,380	--	Synthesized	2014	05/30/2014	600	--	
1976	//1976	888	--	Synthesized	1978	//1978	590	--	Synthesized
1977	//1977	246	--	Synthesized	1979	//1979	548	--	Synthesized
1978	//1978	590	--	Synthesized	1959	//1959	521	--	Synthesized
1979	//1979	548	--	Synthesized	1957	//1957	502	--	Synthesized
1980	//1980	607	--	Synthesized	1950	06/25/1950	501	4.07	
1981	//1981	790	--	Synthesized	1967	//1967	487	--	Synthesized
1982	//1982	874	--	Synthesized	2016	05/23/2016	485	--	
1983	//1983	1,350	--	Synthesized	1952	06/07/1952	472	3.96	
1984	//1984	3,630	--	PT definition	1945	//1945	419	--	Synthesized
1985	//1985	218	--	Synthesized	1999	05/31/1999	417	--	
1986	//1986	835	--	Synthesized	2009	06/23/2009	417	--	
1987	//1987	381	--	Synthesized	1988	//1988	413	--	Synthesized
1988	//1988	413	--	Synthesized	2007	05/04/2007	387	--	
1989	//1989	187	--	Synthesized	1987	//1987	381	--	Synthesized
1990	//1990	191	--	Synthesized	1956	//1956	368	--	Synthesized
1991	//1991	1,010	--	Synthesized	1949	10/30/1948	338	3.25	
1992	//1992	211	--	Synthesized	1958	//1958	337	--	Synthesized
1993	//1993	956	--	Synthesized	1966	//1966	334	--	Synthesized
1994	//1994	229	--	Synthesized	1946	//1946	328	--	Synthesized
1995	//1995	1,910	--	Synthesized	1944	//1944	322	--	Synthesized
1996	//1996	942	--	Synthesized	2012	//2012	317	--	Synthesized
1997	06/04/1997	674	--		2003	05/30/2003	303	--	
1998	06/28/1998	695	--		2015	06/04/2015	282	--	
1999	05/31/1999	417	--		1951	08/28/1951	262	2.89	
2000	05/30/2000	222	--		1940	//1940	253	--	Synthesized
2001	05/06/2001	210	--		1977	//1977	246	--	Synthesized
2002	06/11/2002	196	--		1939	//1939	230	--	Synthesized
2003	05/30/2003	303	--		2004	08/26/2004	230	--	
2004	08/26/2004	230	--		1994	//1994	229	--	Synthesized
2005	06/19/2005	1,380	--		2000	05/30/2000	222	--	
2006	06/14/2006	927	--		1985	//1985	218	--	Synthesized
2007	05/04/2007	387	--		1961	//1961	211	--	Synthesized
2008	06/20/2008	657	--		1992	//1992	211	--	Synthesized
2009	06/23/2009	417	--		2001	05/06/2001	210	--	
2010	06/19/2010	1,590	--		2002	06/11/2002	196	--	
2011	06/10/2011	2,090	--		1990	//1990	191	--	Synthesized
2012	//2012	317	--	Synthesized	1989	//1989	187	--	Synthesized
2013	10/05/2012	161	--		1954	//1954	185	--	Synthesized
2014	05/30/2014	600	--		1943	//1943	169	--	Synthesized
2015	06/04/2015	282	--		2013	10/05/2012	161	--	
2016	05/23/2016	485	--		1941	//1941	140	--	Synthesized

06023000.11 Ruby River near Twin Bridges, Montana
Analysis for regulated period of record
Analysis period of record, water years: 1939–2016
Peak-flow frequency analysis conducted on recorded and synthesized data

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[Water year is the 12-month period from October 1 through September 30 and is designated by the year in which it ends. PILF; potentially influential low flow; MGBT, multiple Grubbs-Beck test]

Contributing drainage area, in square miles	Type of peak-flow frequency analysis
970	MOVE.3

Peak flow, in cubic feet per second, for indicated annual exceedance probability (bold values), in percent								
50	**42.9**	**20**	**10**	**4**	**2**	**1.0**	**0.5**	**0.2**
680	763	1,180	1,590	2,200	2,720	3,300	3,940	4,920

Upper and lower 90-percent confidence intervals, in cubic feet per second, for indicated annual exceedance probability, in percent								
50	**42.9**	**20**	**10**	**4**	**2**	**1.0**	**0.5**	**0.2**
911	1,030	1,690	2,480	4,020	5,730	8,030	11,100	16,800
484	543	816	1,040	1,310	1,470	1,580	1,640	1,640

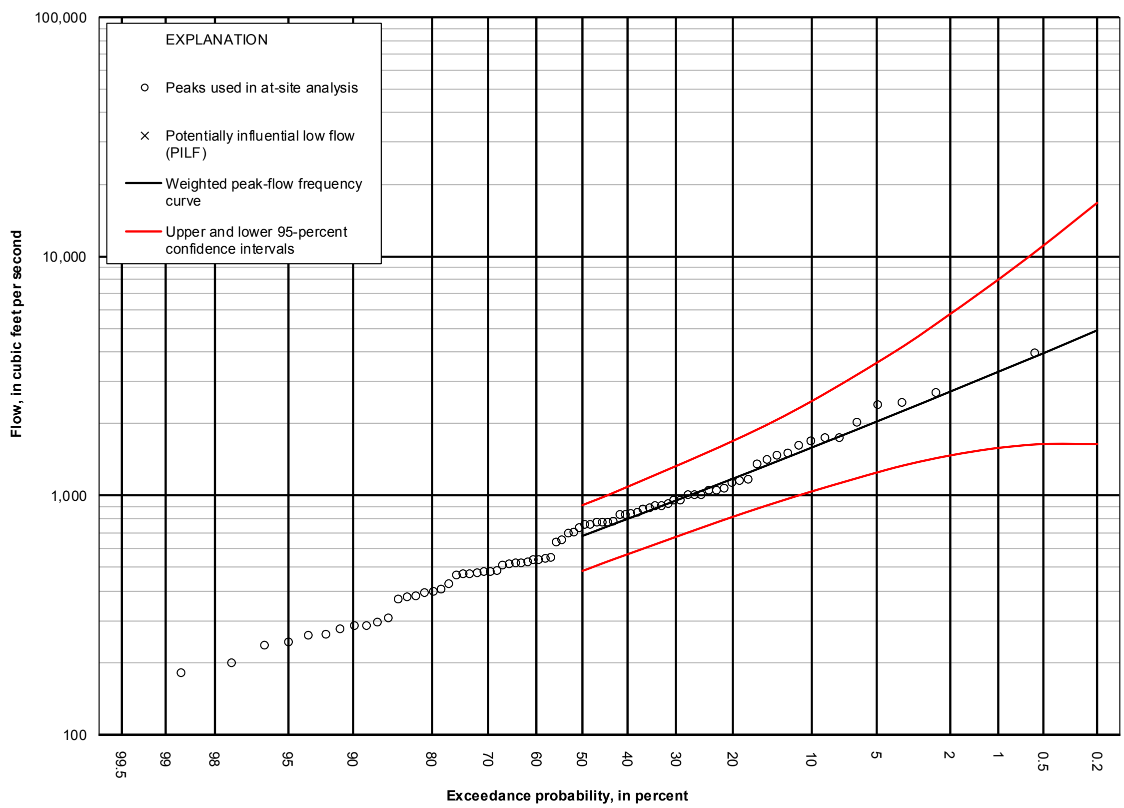

Figure 1. Annual peak flows (plotting positions determined using the Cunnane formulation; Helsel and HIrsch, 2002) and peak-flow frequency curve

[1]Peak flows with a value of zero are not plotted in figure 1 .

[2]In cases where the month, day, or both are not present in the date of a peak flow (as indicated by adjacent slash marks with no intervening values), the month, day, or both are unknown.

[3]Flood-frequency results not reported because of too many values less than the PILF threshold used in the at-site analysis.

[4]Definitions of peak-flow designations used in analysis include:

PT definition: The peak flow is used to define perception thresholds in ungaged historical periods;

Opportunistic: The peak flow was excluded from the analysis because it is outside of the systematic record and was of insufficient magnitude to determine nonexceedance during an ungaged period;

PILF: The peak flow was identified as a potentially influential low flow;

England, J.F. Jr., Cohn, T.A., Faber, B.A., Stedinger, J.R., Thomas Jr., W.O., Veilleux, A.G., Kiang, J.E., and Mason, R.R., 2017, Guidelines for Determining Flood Flow Frequency – Bulletin 17C: U.S. Geological Survey Techniques and Methods book 4, chap. B5, 167 p., https://dx.doi.org/10.3133/tm4–B5/, accessed October 2, 2017 at https://acwi.gov/hydrology/Frequency/b17c/bulletin17c-draft-for-soh-31Aug2017.pdf.

06023000.11 Ruby River near Twin Bridges, Montana
Analysis for regulated period of record
Analysis period of record, water years: 1939–2016
Peak-flow frequency analysis conducted on recorded and synthesized data

Table 1-1 Table 1-2 Table 1-3 Table 1-4 Table 1-5 Table 1-6 Table 1-7 Table 1-8

[Water year is the 12-month period from October 1 through September 30 and is designated by the year in which it ends.]

Peak-flow data[2]					Ranked (largest to smallest) peak-flow data[2]				
Water year	Date[3]	Peak flow, in cubic feet per second	Gage height, in feet	Peak-flow designation in analysis[4]	Water year	Date[3]	Peak flow, in cubic feet per second	Gage height, in feet	Peak-flow designation in analysis[4]
1939	//1939	379	--	Synthesized	1984	//1984	3,910	--	
1940	//1940	401	--	Synthesized	2011	//2011	2,660	--	Synthesized
1941	//1941	283	--	Synthesized	1995	//1995	2,430	--	Synthesized
1942	06/12/1942	1,040	--		1991	//1991	2,390	--	Synthesized
1943	06/21/1943	466	--		2010	//2010	2,010	--	Synthesized
1944	//1944	462	--	Synthesized	1970	//1970	1,740	--	Synthesized
1945	//1945	540	--	Synthesized	2005	//2005	1,740	--	Synthesized
1946	//1946	467	--	Synthesized	1996	//1996	1,670	--	Synthesized
1947	06/12/1947	1,500	6.89		1975	//1975	1,610	--	Synthesized
1948	06/04/1948	1,470	6.84		1947	06/12/1947	1,500	6.89	
1949	03/23/1949	395	4.35		1948	06/04/1948	1,470	6.84	
1950	06/26/1950	547	2.00		1983	//1983	1,400	--	Synthesized
1951	10/06/1950	294	2.00		1964	06/22/1964	1,350	7.14	
1952	06/07/1952	839	2.00		2006	//2006	1,160	--	Synthesized
1953	06/19/1953	903	5.65		1976	//1976	1,150	--	Synthesized
1954	11/26/1953	235	2.00		1986	//1986	1,120	--	Synthesized
1955	06/19/1955	473	2.00		1973	//1973	1,060	--	Synthesized
1956	05/30/1956	475	4.87		1942	06/12/1942	1,040	--	
1957	06/09/1957	754	5.86		1971	//1971	1,040	--	Synthesized
1958	06/25/1958	536	2.00		1981	06/08/1981	1,000	6.95	
1959	06/27/1959	524	2.00		1982	//1982	996	--	Synthesized
1960	05/15/1960	637	2.00		1993	//1993	996	--	Synthesized
1961	07/06/1961	262	2.00		1963	06/22/1963	944	6.61	
1962	06/17/1962	779	2.00		1967	//1967	943	--	Synthesized
1963	06/22/1963	944	6.61		1965	06/26/1965	916	6.54	
1964	06/22/1964	1,350	7.14		1953	06/19/1953	903	5.65	
1965	06/26/1965	916	6.54		1968	//1968	903	--	Synthesized
1966	//1966	479	--	Synthesized	1972	//1972	877	--	Synthesized
1967	//1967	943	--	Synthesized	1998	//1998	870	--	Synthesized
1968	//1968	903	--	Synthesized	1997	//1997	843	--	Synthesized
1969	//1969	826	--	Synthesized	1952	06/07/1952	839	2.00	
1970	//1970	1,740	--	Synthesized	1969	//1969	826	--	Synthesized
1971	//1971	1,040	--	Synthesized	2008	//2008	822	--	Synthesized
1972	//1972	877	--	Synthesized	1962	06/17/1962	779	2.00	
1973	//1973	1,060	--	Synthesized	1980	06/13/1980	765	6.73	
1974	//1974	764	--	Synthesized	1974	//1974	764	--	Synthesized
1975	//1975	1,610	--	Synthesized	1988	//1988	764	--	Synthesized
1976	//1976	1,150	--	Synthesized	1957	06/09/1957	754	5.86	
1977	//1977	509	--	Synthesized	2014	//2014	750	--	Synthesized
1978	//1978	695	--	Synthesized	1979	//1979	727	--	Synthesized
1979	//1979	727	--	Synthesized	1978	//1978	695	--	Synthesized
1980	06/13/1980	765	6.73		1990	//1990	691	--	Synthesized
1981	06/08/1981	1,000	6.95		1985	//1985	650	--	Synthesized
1982	//1982	996	--	Synthesized	1960	05/15/1960	637	2.00	
1983	//1983	1,400	--	Synthesized	1950	06/26/1950	547	2.00	
1984	//1984	3,910	--		1945	//1945	540	--	Synthesized
1985	//1985	650	--	Synthesized	1958	06/25/1958	536	2.00	
1986	//1986	1,120	--	Synthesized	2016	05/23/2016	536	3.74	
1987	//1987	364	--	Synthesized	1959	06/27/1959	524	2.00	
1988	//1988	764	--	Synthesized	1999	//1999	519	--	Synthesized
1989	//1989	426	--	Synthesized	2009	//2009	519	--	Synthesized
1990	//1990	691	--	Synthesized	2012	//2012	511	--	Synthesized
1991	//1991	2,390	--	Synthesized	1977	//1977	509	--	Synthesized
1992	//1992	181	--	Synthesized	2007	//2007	481	--	Synthesized
1993	//1993	996	--	Synthesized	1966	//1966	479	--	Synthesized
1994	//1994	307	--	Synthesized	1956	05/30/1956	475	4.87	
1995	//1995	2,430	--	Synthesized	1955	06/19/1955	473	2.00	
1996	//1996	1,670	--	Synthesized	1946	//1946	467	--	Synthesized
1997	//1997	843	--	Synthesized	1943	06/21/1943	466	--	
1998	//1998	870	--	Synthesized	1944	//1944	462	--	Synthesized
1999	//1999	519	--	Synthesized	1989	//1989	426	--	Synthesized
2000	//2000	274	--	Synthesized	1940	//1940	401	--	Synthesized
2001	//2001	259	--	Synthesized	1949	03/23/1949	395	4.35	
2002	//2002	242	--	Synthesized	2015	06/05/2015	390	3.21	
2003	//2003	375	--	Synthesized	1939	//1939	379	--	Synthesized
2004	//2004	284	--	Synthesized	2003	//2003	375	--	Synthesized
2005	//2005	1,740	--	Synthesized	1987	//1987	364	--	Synthesized
2006	//2006	1,160	--	Synthesized	1994	//1994	307	--	Synthesized
2007	//2007	481	--	Synthesized	1951	10/06/1950	294	2.00	
2008	//2008	822	--	Synthesized	2004	//2004	284	--	Synthesized
2009	//2009	519	--	Synthesized	1941	//1941	283	--	Synthesized
2010	//2010	2,010	--	Synthesized	2000	//2000	274	--	Synthesized
2011	//2011	2,660	--	Synthesized	1961	07/06/1961	262	2.00	
2012	//2012	511	--	Synthesized	2001	//2001	259	--	Synthesized
2013	//2013	198	--	Synthesized	2002	//2002	242	--	Synthesized
2014	//2014	750	--	Synthesized	1954	11/26/1953	235	2.00	
2015	06/05/2015	390	3.21		2013	//2013	198	--	Synthesized
2016	05/23/2016	536	3.74		1992	//1992	181	--	Synthesized

06026500.21 Jefferson River near Twin Bridges, Montana
Analysis for total period of record
Analysis period of record, water years: 1895; 1897–1905; 1911–16; 1921–2016
Peak-flow frequency analysis conducted on recorded and synthesized data

Table 1-1 Table 1-2 Table 1-3 Table 1-4 Table 1-5 Table 1-6 Table 1-7 Table 1-8

[Water year is the 12-month period from October 1 through September 30 and is designated by the year in which it ends. PILF; potentially influential low flow; MGBT, multiple Grubbs-Beck test]

Contributing drainage area, in square miles									Type of peak-flow frequency analysis
7,616									MOVE.3
Peak flow, in cubic feet per second, for indicated annual exceedance probability (bold values), in percent									
	50	**42.9**	**20**	**10**	**4**	**2**	**1.0**	**0.5**	**0.2**
	8,260	8,880	11,500	13,400	15,700	17,300	18,800	20,200	22,000
Upper and lower 90-percent confidence intervals, in cubic feet per second, for indicated annual exceedance probability, in percent									
	50	**42.9**	**20**	**10**	**4**	**2**	**1.0**	**0.5**	**0.2**
	8,950	9,650	12,600	14,900	18,000	20,400	22,900	25,600	29,500
	7,420	8,100	10,600	12,300	14,300	15,500	16,600	17,500	18,600

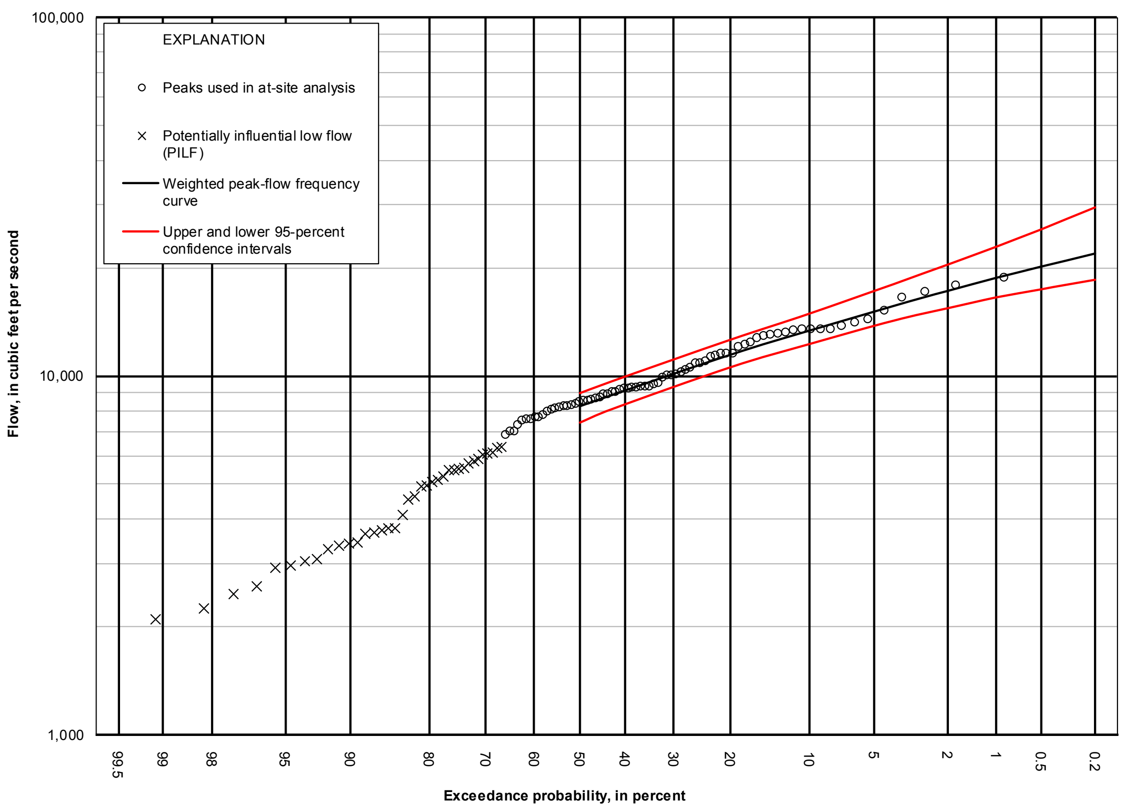

Figure 1. Annual peak flows (plotting positions determined using the Cunnane formulation; Helsel and HIrsch, 2002) and peak-flow frequency curve

[1]Peak flows with a value of zero are not plotted in figure 1 .
[2]In cases where the month, day, or both are not present in the date of a peak flow (as indicated by adjacent slash marks with no intervening values), the month, day, or both are unknown.
[3]Flood-frequency results not reported because of too many values less than the PILF threshold used in the at-site analysis.
[4]Definitions of peak-flow designations used in analysis include:
PT definition: The peak flow is used to define perception thresholds in ungaged historical periods;
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PILF: The peak flow was identified as a potentially influential low flow;
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06026500.21 Jefferson River near Twin Bridges, Montana
Analysis for total period of record
Analysis period of record, water years: 1895; 1897–1905; 1911–16; 1921–2016
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Table 1-1 Table 1-2 Table 1-3 Table 1-4 Table 1-5 Table 1-6 Table 1-7 Table 1-8

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Water year	Date[3]	Peak flow, in cubic feet per second	Gage height, in feet	Peak-flow designation in analysis[4]	Water year	Date[3]	Peak flow, in cubic feet per second	Gage height, in feet	Peak-flow designation in analysis[4]
1895	//1895	3,090	--	PILF; synthesized	1927	06/15/1927	20,300	10.00	Dam failure
1897	//1897	9,990	--	Synthesized	1899	//1899	18,700	--	Synthesized
1898	//1898	9,190	--	Synthesized	1948	//1948	17,800	--	Synthesized
1899	//1899	18,700	--	Synthesized	1913	06/15/1913	17,100	9.00	
1900	//1900	9,340	--	Synthesized	1964	06/10/1964	16,500	9.04	
1901	//1901	8,470	--	Synthesized	1997	06/09/1997	15,200	12.42	
1902	//1902	9,340	--	Synthesized	1981	//1981	14,300	--	Synthesized
1903	//1903	8,870	--	Synthesized	1995	06/08/1995	14,000	12.60	
1904	//1904	9,430	--	Synthesized	1984	//1984	13,700	--	Synthesized
1905	//1905	5,040	--	PILF; synthesized	1916	06/23/1916	13,500	7.75	
1911	06/16/1911	9,280	6.40		1921	06/11/1921	13,500	7.80	
1912	06/15/1912	13,400	7.90		1922	06/11/1922	13,500	7.80	
1913	06/15/1913	17,100	9.00		1975	//1975	13,500	--	Synthesized
1914	06/06/1914	9,030	6.25		1912	06/15/1912	13,400	7.90	
1915	06/15/1915	7,260	5.60		1942	05/28/1942	13,200	--	
1916	06/23/1916	13,500	7.75		1996	06/11/1996	13,100	12.00	
1921	06/11/1921	13,500	7.80		2011	06/12/2011	13,000	9.70	
1922	06/11/1922	13,500	7.80		1972	06/03/1972	12,900	8.25	
1923	06/27/1923	7,530	5.70		1965	06/18/1965	12,700	8.13	
1924	05/19/1924	5,240	4.80	PILF	1938	07/04/1938	12,400	7.50	
1925	06/06/1925	8,890	6.20		1976	//1976	12,200	--	Synthesized
1926	04/20/1926	4,900	4.65	PILF	1956	//1956	12,000	--	Synthesized
1927	06/15/1927	20,300	10.00	Dam failure	1947	//1947	11,500	--	Synthesized
1928	05/13/1928	11,400	7.10		1974	//1974	11,500	--	Synthesized
1929	06/19/1929	8,070	5.80		2010	06/19/2010	11,500	9.33	
1930	04/10/1930	7,480	5.40		1928	05/13/1928	11,400	7.10	
1931	04/14/1931	2,460	3.40	PILF	1982	//1982	11,300	--	Synthesized
1932	06/19/1932	6,960	5.30		1953	//1953	11,000	--	Synthesized
1933	06/11/1933	9,130	6.10		1991	//1991	10,800	--	Synthesized
1934	05/11/1934	3,420	3.98	PILF	2003	06/01/2003	10,800	10.31	
1935	06/14/1935	4,960	4.70	PILF	1970	06/10/1970	10,500	7.69	
1936	06/05/1936	7,000	5.47		1969	05/22/1969	10,400	7.51	
1937	05/08/1937	2,090	3.39	PILF	1943	06/01/1943	10,200	--	
1938	07/04/1938	12,400	7.50		1967	06/08/1967	10,100	7.55	
1939	05/06/1939	5,470	5.00	PILF	1971	06/02/1971	10,000	7.34	
1940	//1940	3,760	--	PILF; synthesized	1897	//1897	9,990	--	Synthesized
1941	//1941	6,110	--	PILF; synthesized	1944	//1944	9,870	--	Synthesized
1942	05/28/1942	13,200	--		1957	//1957	9,520	--	Synthesized
1943	06/01/1943	10,200	--		1904	//1904	9,430	--	Synthesized
1944	//1944	9,870	--	Synthesized	2014	05/30/2014	9,350	8.35	
1945	//1945	5,680	--	PILF; synthesized	1900	//1900	9,340	--	Synthesized
1946	//1946	6,040	--	PILF; synthesized	1902	//1902	9,340	--	Synthesized
1947	//1947	11,500	--	Synthesized	1911	06/16/1911	9,280	6.40	
1948	//1948	17,800	--	Synthesized	1950	//1950	9,250	--	Synthesized
1949	//1949	7,770	--	Synthesized	1999	05/31/1999	9,220	10.08	
1950	//1950	9,250	--	Synthesized	1898	//1898	9,190	--	Synthesized
1951	//1951	7,660	--	Synthesized	1933	06/11/1933	9,130	6.10	
1952	//1952	7,940	--	Synthesized	1914	06/06/1914	9,030	6.25	
1953	//1953	11,000	--	Synthesized	2009	06/02/2009	9,000	9.58	
1954	//1954	5,130	--	PILF; synthesized	1925	06/06/1925	8,890	6.20	
1955	//1955	6,320	--	PILF; synthesized	1903	//1903	8,870	--	Synthesized
1956	//1956	12,000	--	Synthesized	1983	//1983	8,680	--	Synthesized
1957	//1957	9,520	--	Synthesized	1980	//1980	8,630	--	Synthesized
1958	05/27/1958	8,140	7.04		1978	//1978	8,580	--	Synthesized
1959	06/10/1959	8,040	6.94		1986	//1986	8,500	--	Synthesized
1960	03/29/1960	6,270	--	PILF	2006	06/11/2006	8,500	9.44	
1961	06/13/1961	5,460	5.89	PILF	1901	//1901	8,470	--	Synthesized
1962	06/16/1962	6,820	6.42		2008	05/22/2008	8,320	9.58	
1963	06/25/1963	8,240	2.00		1998	06/27/1998	8,300	9.66	
1964	06/10/1964	16,500	9.04		1963	06/25/1963	8,240	2.00	
1965	06/18/1965	12,700	8.13		1968	06/12/1968	8,190	6.71	
1966	04/05/1966	3,290	4.53	PILF	1958	05/27/1958	8,140	7.04	
1967	06/08/1967	10,100	7.55		1929	06/19/1929	8,070	5.80	
1968	06/12/1968	8,190	6.71		1959	06/10/1959	8,040	6.94	
1969	05/22/1969	10,400	7.51		1952	//1952	7,940	--	Synthesized
1970	06/10/1970	10,500	7.69		1949	//1949	7,770	--	Synthesized
1971	06/02/1971	10,000	7.34		1979	//1979	7,680	--	Synthesized
1972	06/03/1972	12,900	8.25		1951	//1951	7,660	--	Synthesized
1973	//1973	2,910	--	PILF; synthesized	1923	06/27/1923	7,530	5.70	
1974	//1974	11,500	--	Synthesized	2012	04/28/2012	7,530	7.34	
1975	//1975	13,500	--	Synthesized	1930	04/10/1930	7,480	5.40	
1976	//1976	12,200	--	Synthesized	1915	06/15/1915	7,260	5.60	
1977	//1977	5,480	--	PILF; synthesized	1936	06/05/1936	7,000	5.47	
1978	//1978	8,580	--	Synthesized	1932	06/19/1932	6,960	5.30	
1979	//1979	7,680	--	Synthesized	1962	06/16/1962	6,820	6.42	
1980	//1980	8,630	--	Synthesized	1955	//1955	6,320	--	PILF; synthesi
1981	//1981	14,300	--	Synthesized	1960	03/29/1960	6,270	--	PILF
1982	//1982	11,300	--	Synthesized	1941	//1941	6,110	--	PILF; synthesi
1983	//1983	8,680	--	Synthesized	2002	06/03/2002	6,050	8.37	PILF
1984	//1984	13,700	--	Synthesized	1946	//1946	6,040	--	PILF; synthesi
1985	//1985	5,850	--	PILF; synthesized	1985	//1985	5,850	--	PILF; synthesi
1986	//1986	8,500	--	Synthesized	1993	//1993	5,770	--	PILF; synthesi
1987	//1987	3,350	--	PILF; synthesized	1945	//1945	5,680	--	PILF; synthesi
1988	//1988	3,710	--	PILF; synthesized	2016	05/22/2016	5,540	6.85	PILF
1989	//1989	3,620	--	PILF; synthesized	1977	//1977	5,480	--	PILF; synthesi
1990	//1990	3,750	--	PILF; synthesized	1939	05/06/1939	5,470	5.00	PILF
1991	//1991	10,800	--	Synthesized	1961	06/13/1961	5,460	5.89	PILF
1992	//1992	2,250	--	PILF; synthesized	1924	05/19/1924	5,240	4.80	PILF
1993	//1993	5,770	--	PILF; synthesized	1954	//1954	5,130	--	PILF; synthesi
1994	04/24/1994	3,400	7.50	PILF	1905	//1905	5,040	--	PILF; synthesi
1995	06/08/1995	14,000	12.60		1935	06/14/1935	4,960	4.70	PILF
1996	06/11/1996	13,100	12.00		1926	04/20/1926	4,900	4.65	PILF
1997	06/09/1997	15,200	12.42		2007	06/09/2007	4,610	7.47	PILF
1998	06/27/1998	8,300	9.66		2015	06/04/2015	4,500	6.35	PILF
1999	05/31/1999	9,220	10.08		2005	05/22/2005	4,100	6.96	PILF
2000	05/30/2000	2,950	6.33	PILF	1940	//1940	3,760	--	PILF; synthesi
2001	06/16/2001	3,030	6.39	PILF	1990	//1990	3,750	--	PILF; synthesi
2002	06/03/2002	6,050	8.37	PILF	1988	//1988	3,710	--	PILF; synthesi
2003	06/01/2003	10,800	10.31		2013	05/29/2013	3,650	5.64	PILF
2004	06/11/2004	2,580	5.83	PILF	1989	//1989	3,620	--	PILF; synthesi
2005	05/22/2005	4,100	6.96	PILF	1934	05/11/1934	3,420	3.98	PILF
2006	06/11/2006	8,500	9.44		1994	04/24/1994	3,400	7.50	PILF
2007	06/09/2007	4,610	7.47	PILF	1987	//1987	3,350	--	PILF; synthesi
2008	05/22/2008	8,320	9.58		1966	04/05/1966	3,290	4.53	PILF
2009	06/02/2009	9,000	9.58		1895	//1895	3,090	--	PILF; synthesi
2010	06/19/2010	11,500	9.33		2001	06/16/2001	3,030	6.39	PILF
2011	06/12/2011	13,000	9.70		2000	05/30/2000	2,950	6.33	PILF
2012	04/28/2012	7,530	7.34		1973	//1973	2,910	--	PILF; synthesi
2013	05/29/2013	3,650	5.64	PILF	2004	06/11/2004	2,580	5.83	PILF
2014	05/30/2014	9,350	8.35		1931	04/14/1931	2,460	3.40	PILF
2015	06/04/2015	4,500	6.35	PILF	1992	//1992	2,250	--	PILF; synthesi
2016	05/22/2016	5,540	6.85	PILF	1937	05/08/1937	2,090	3.39	PILF

06036650.21 Jefferson River near Three Forks, Montana
Analysis for total period of record
Analysis period of record, water years: 1895; 1897–1905; 1911–16; 1921–26; 1928–2016
Peak-flow frequency analysis conducted on recorded and synthesized data

Table 1-1 Table 1-2 Table 1-3 Table 1-4 Table 1-5 Table 1-6 Table 1-7 Table 1-8

[Water year is the 12-month period from October 1 through September 30 and is designated by the year in which it ends. PILF; potentially influential low flow; MGBT, multiple Grubbs-Beck test]

Contributing drainage area, in square miles								Type of peak-flow frequency analysis
9,558								MOVE.3
Peak flow, in cubic feet per second, for indicated annual exceedance probability (bold values), in percent								
50	**42.9**	**20**	**10**	**4**	**2**	**1.0**	**0.5**	**0.2**
9,040	9,750	12,700	15,000	17,800	19,800	21,700	23,600	26,000
Upper and lower 90-percent confidence intervals, in cubic feet per second, for indicated annual exceedance probability, in percent								
50	**42.9**	**20**	**10**	**4**	**2**	**1.0**	**0.5**	**0.2**
9,820	10,600	14,000	16,800	20,600	23,700	27,000	30,800	36,300
8,100	8,870	11,700	13,700	16,000	17,600	19,000	20,300	21,800

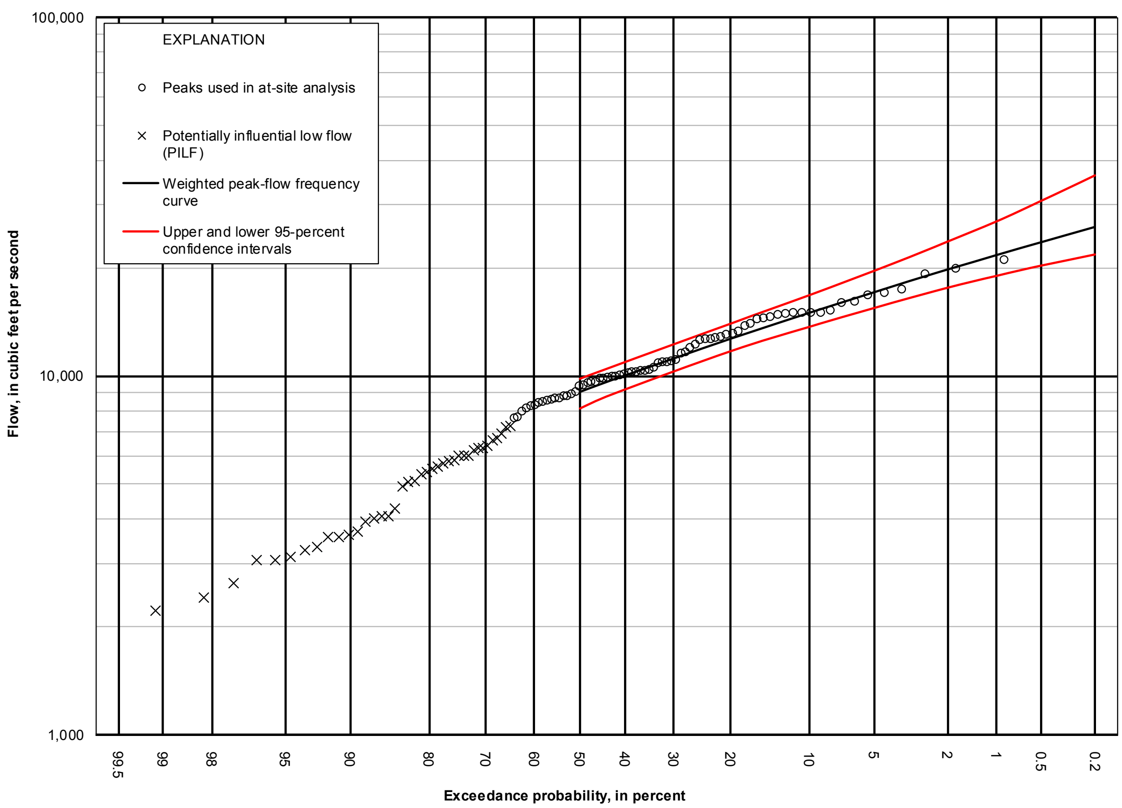


Figure 1. Annual peak flows (plotting positions determined using the Cunnane formulation; Helsel and HIrsch, 2002) and peak-flow frequency curve

[1]Peak flows with a value of zero are not plotted in figure 1 .
[2]In cases where the month, day, or both are not present in the date of a peak flow (as indicated by adjacent slash marks with no intervening values), the month, day, or both are unknown.
[3]Flood-frequency results not reported because of too many values less than the PILF threshold used in the at-site analysis.
[4]Definitions of peak-flow designations used in analysis include:
PT definition: The peak flow is used to define perception thresholds in ungaged historical periods;
Opportunistic: The peak flow was excluded from the analysis because it is outside of the systematic record and was of insufficient magnitude to determine nonexceedance during an ungaged period;
PILF: The peak flow was identified as a potentially influential low flow;

England, J.F. Jr., Cohn, T.A., Faber, B.A., Stedinger, J.R., Thomas Jr., W.O., Veilleux, A.G., Kiang, J.E., and Mason, R.R., 2017, Guidelines for Determining Flood Flow Frequency – Bulletin 17C: U.S. Geological Survey Techniques and Methods book 4, chap. B5, 167 p., https://dx.doi.org/10.3133/tm4–B5/, accessed October 2, 2017 at https://acwi.gov/hydrology/Frequency/b17c/bulletin17c-draft-for-soh-31Aug2017.pdf.

06036650.21 Jefferson River near Three Forks, Montana
Analysis for total period of record
Analysis period of record, water years: 1895; 1897–1905; 1911–16; 1921–26; 1928–2016
Peak-flow frequency analysis conducted on recorded and synthesized data

Table 1-1 Table 1-2 Table 1-3 Table 1-4 Table 1-5 Table 1-6 Table 1-7 Table 1-8

[Water year is the 12-month period from October 1 through September 30 and is designated by the year in which it ends.]

Peak-flow data[2]					Ranked (largest to smallest) peak-flow data[2]				
Water year	Date[3]	Peak flow, in cubic feet per second	Gage height, in feet	Peak-flow designation in analysis[4]	Water year	Date[3]	Peak flow, in cubic feet per second	Gage height, in feet	Peak-flow designation in analysis[4]
1895	05/24/1895	3,330	--	PILF	1899	06/23/1899	21,000	--	
1897	05/19/1897	11,040	--		1948	06/06/1948	19,900	10.97	
1898	05/30/1898	10,130	--		1913	//1913	19,100	--	Synthesized
1899	06/23/1899	21,000	--		2011	06/12/2011	17,400	9.38	
1900	05/16/1900	10,300	--		1995	06/09/1995	17,000	9.00	
1901	05/20/1901	9,325	--		1997	06/11/1997	16,700	9.20	
1902	05/31/1902	10,300	--		1964	06/12/1964	16,000	10.16	
1903	06/07/1903	9,770	--		1981	05/24/1981	15,900	8.06	
1904	05/26/1904	10,400	--		1984	06/24/1984	15,200	8.51	
1905	06/28/1905	5,485	--	PILF	1916	//1916	15,000	--	Synthesized
1911	//1911	10,200	--	Synthesized	1921	//1921	15,000	--	Synthesized
1912	//1912	14,900	--	Synthesized	1922	//1922	15,000	--	Synthesized
1913	//1913	19,100	--	Synthesized	1975	06/21/1975	15,000	10.12	
1914	//1914	9,940	--	Synthesized	1912	//1912	14,900	--	Synthesized
1915	//1915	7,950	--	Synthesized	2010	06/20/2010	14,700	8.77	
1916	//1916	15,000	--	Synthesized	1942	05/30/1942	14,500	9.79	
1921	//1921	15,000	--	Synthesized	1965	06/19/1965	14,400	9.42	
1922	//1922	15,000	--	Synthesized	1972	//1972	14,300	--	Synthesized
1923	//1923	8,250	--	Synthesized	1976	//1976	13,900	--	Synthesized
1924	//1924	5,690	--	PILF; synthesized	1938	//1938	13,700	--	Synthesized
1925	//1925	9,780	--	Synthesized	1956	05/29/1956	13,300	9.37	
1926	//1926	5,320	--	PILF; synthesized	1974	//1974	13,100	--	Synthesized
1928	//1928	12,600	--	Synthesized	1996	06/12/1996	13,000	8.17	
1929	//1929	8,860	--	Synthesized	1947	05/12/1947	12,800	9.68	
1930	//1930	8,190	--	Synthesized	1943	06/03/1943	12,700	9.09	
1931	//1931	2,630	--	PILF; synthesized	1928	//1928	12,600	--	Synthesized
1932	//1932	7,610	--	Synthesized	1967	06/03/1967	12,600	8.91	
1933	//1933	10,000	--	Synthesized	1982	06/19/1982	12,500	7.63	
1934	//1934	3,680	--	PILF; synthesized	1953	06/16/1953	12,200	9.00	
1935	//1935	5,380	--	PILF; synthesized	1991	06/09/1991	11,900	7.63	
1936	//1936	7,660	--	Synthesized	1970	//1970	11,600	--	Synthesized
1937	//1937	2,220	--	PILF; synthesized	2003	06/02/2003	11,500	7.72	
1938	//1938	13,700	--	Synthesized	1897	05/19/1897	11,040	--	
1939	05/26/1939	6,000	5.91	PILF	1971	//1971	11,000	--	Synthesized
1940	05/29/1940	4,060	5.84	PILF	1944	06/13/1944	10,900	8.50	
1941	06/08/1941	6,680	7.33	PILF	1969	05/23/1969	10,900	8.46	
1942	05/30/1942	14,500	9.79		1999	05/31/1999	10,800	7.27	
1943	06/03/1943	12,700	9.09		1957	05/23/1957	10,500	8.35	
1944	06/13/1944	10,900	8.50		1904	05/26/1904	10,400	--	
1945	06/10/1945	6,200	6.75	PILF	1900	05/16/1900	10,300	--	
1946	05/31/1946	6,600	7.05	PILF	1902	05/31/1902	10,300	--	
1947	05/12/1947	12,800	9.68		1911	//1911	10,200	--	Synthesized
1948	06/06/1948	19,900	10.97		1950	06/22/1950	10,200	8.29	
1949	06/04/1949	8,540	7.91		1898	05/30/1898	10,130	--	
1950	06/22/1950	10,200	8.29		2009	06/02/2009	10,100	7.47	
1951	05/26/1951	8,410	7.85		1933	//1933	10,000	--	Synthesized
1952	05/17/1952	8,730	7.80		1914	//1914	9,940	--	Synthesized
1953	06/16/1953	12,200	9.00		1968	06/14/1968	9,920	8.08	
1954	07/01/1954	5,580	6.37	PILF	2014	05/31/2014	9,840	7.34	
1955	06/18/1955	6,910	6.98	PILF	1925	//1925	9,780	--	Synthesized
1956	05/29/1956	13,300	9.37		1903	06/07/1903	9,770	--	
1957	05/23/1957	10,500	8.35		1978	//1978	9,590	--	Synthesized
1958	05/27/1958	8,780	7.76		1983	06/01/1983	9,560	6.77	
1959	06/09/1959	8,650	7.77		1980	06/17/1980	9,500	6.77	
1960	06/06/1960	5,960	6.57	PILF	1986	06/02/1986	9,360	6.87	
1961	05/31/1961	5,790	6.48	PILF	1901	05/20/1901	9,325	--	
1962	06/17/1962	7,190	7.02	PILF	1998	06/28/1998	9,020	7.13	
1963	06/08/1963	8,110	7.42		1929	//1929	8,860	--	Synthesized
1964	06/12/1964	16,000	10.16		1958	05/27/1958	8,780	7.76	
1965	06/19/1965	14,400	9.42		1952	05/17/1952	8,730	7.80	
1966	05/12/1966	3,560	5.13	PILF	1959	06/09/1959	8,650	7.77	
1967	06/03/1967	12,600	8.91		2008	06/07/2008	8,600	7.20	
1968	06/14/1968	9,920	8.08		1949	06/04/1949	8,540	7.91	
1969	05/23/1969	10,900	8.46		2006	06/12/2006	8,480	6.97	
1970	//1970	11,600	--	Synthesized	1979	05/29/1979	8,430	6.40	
1971	//1971	11,000	--	Synthesized	1951	05/26/1951	8,410	7.85	
1972	//1972	14,300	--	Synthesized	1923	//1923	8,250	--	Synthesized
1973	//1973	3,070	--	PILF; synthesized	1930	//1930	8,190	--	Synthesized
1974	//1974	13,100	--	Synthesized	1963	06/08/1963	8,110	7.42	
1975	06/21/1975	15,000	10.12		1915	//1915	7,950	--	Synthesized
1976	//1976	13,900	--	Synthesized	1936	//1936	7,660	--	Synthesized
1977	//1977	5,980	--	PILF; synthesized	1932	//1932	7,610	--	Synthesized
1978	//1978	9,590	--	Synthesized	2012	04/29/2012	7,220	6.64	PILF
1979	05/29/1979	8,430	6.40		1962	06/17/1962	7,190	7.02	PILF
1980	06/17/1980	9,500	6.77		1955	06/18/1955	6,910	6.98	PILF
1981	05/24/1981	15,900	8.06		1941	06/08/1941	6,680	7.33	PILF
1982	06/19/1982	12,500	7.63		1946	05/31/1946	6,600	7.05	PILF
1983	06/01/1983	9,560	6.77		1985	04/14/1985	6,390	5.82	PILF
1984	06/24/1984	15,200	8.51		1993	05/22/1993	6,300	5.79	PILF
1985	04/14/1985	6,390	5.82	PILF	2002	06/04/2002	6,270	6.17	PILF
1986	06/02/1986	9,360	6.87		1945	06/10/1945	6,200	6.75	PILF
1987	05/29/1987	3,610	4.67	PILF	1939	05/26/1939	6,000	5.91	PILF
1988	06/03/1988	4,010	4.86	PILF	1977	//1977	5,980	--	PILF; synthesi
1989	05/12/1989	3,910	4.60	PILF	1960	06/06/1960	5,960	6.57	PILF
1990	06/12/1990	4,050	4.56	PILF	2016	05/23/2016	5,830	6.06	PILF
1991	06/09/1991	11,900	7.63		1961	05/31/1961	5,790	6.48	PILF
1992	07/05/1992	2,400	3.95	PILF	1924	//1924	5,690	--	PILF; synthesi
1993	05/22/1993	6,300	5.79	PILF	1954	07/01/1954	5,580	6.37	PILF
1994	04/25/1994	4,270	5.01	PILF	1905	06/28/1905	5,485	--	PILF
1995	06/09/1995	17,000	9.00		1935	//1935	5,380	--	PILF; synthesi
1996	06/12/1996	13,000	8.17		1926	//1926	5,320	--	PILF; synthesi
1997	06/11/1997	16,700	9.20		2015	06/04/2015	5,090	5.75	PILF
1998	06/28/1998	9,020	7.13		2005	05/22/2005	5,040	5.64	PILF
1999	05/31/1999	10,800	7.27		2007	06/10/2007	4,900	5.68	PILF
2000	05/31/2000	3,060	4.76	PILF	1994	04/25/1994	4,270	5.01	PILF
2001	06/16/2001	3,270	4.89	PILF	1940	05/29/1940	4,060	5.84	PILF
2002	06/04/2002	6,270	6.17	PILF	1990	06/12/1990	4,050	4.56	PILF
2003	06/02/2003	11,500	7.72		1988	06/03/1988	4,010	4.86	PILF
2004	06/12/2004	3,120	4.71	PILF	1989	05/12/1989	3,910	4.60	PILF
2005	05/22/2005	5,040	5.64	PILF	1934	//1934	3,680	--	PILF; synthesi
2006	06/12/2006	8,480	6.97		1987	05/29/1987	3,610	4.67	PILF
2007	06/10/2007	4,900	5.68	PILF	1966	05/12/1966	3,560	5.13	PILF
2008	06/07/2008	8,600	7.20		2013	05/30/2013	3,560	5.06	PILF
2009	06/02/2009	10,100	7.47		1895	05/24/1895	3,330	--	PILF
2010	06/20/2010	14,700	8.77		2001	06/16/2001	3,270	4.89	PILF
2011	06/12/2011	17,400	9.38		2004	06/12/2004	3,120	4.71	PILF
2012	04/29/2012	7,220	6.64	PILF	1973	//1973	3,070	--	PILF; synthesi
2013	05/30/2013	3,560	5.06	PILF	2000	05/31/2000	3,060	4.76	PILF
2014	05/31/2014	9,840	7.34		1931	//1931	2,630	--	PILF; synthesi
2015	06/04/2015	5,090	5.75	PILF	1992	07/05/1992	2,400	3.95	PILF
2016	05/23/2016	5,830	6.06	PILF	1937	//1937	2,220	--	PILF; synthesi

1% ‘plus’ Documentation

Analysis		0.5	0.4292	0.4	0.3	0.2	0.1	0.05	0.04	0.025	0.02	0.01	0.005	0.002
6019500.00	estimate	937.5	1000	1029	1143	1303	1585	1887	1990	2216	2329	2702	3115	3730
	84% CI-lower	877.2	933.8	959.7	1064	1208	1448	1688	1766	1932	2013	2269	2537	2911
	84% CI-upper	1001	1071	1103	1234	1423	1788	2241	2411	2813	3026	3800	4768	6430
6020600.10	estimate	915.6	986.9	1019	1143	1309	1584	1858	1946	2136	2227	2516	2815	3230
	84% CI-lower	839.1	904.6	933.6	1047	1195	1430	1651	1720	1862	1929	2131	2328	2583
	84% CI-upper	999	1078	1114	1254	1446	1784	2155	2284	2573	2719	3211	3768	4617
6020600.11	estimate	849.4	913.6	942.4	1056	1209	1468	1731	1818	2004	2095	2387	2696	3132
	84% CI-lower	791.6	851.1	877.6	981.6	1120	1344	1560	1628	1771	1839	2049	2259	2539
	84% CI-upper	911.6	982.1	1014	1141	1318	1641	2006	2135	2425	2573	3078	3659	4564
6021500.10	estimate	366.1	407.1	425.4	497.4	594.3	753.6	909.7	959.7	1065	1115	1271	1427	1636
	84% CI-lower	282.4	316.4	331.4	389.3	465.4	589.1	702.2	734.9	797.5	824.2	897.2	957.3	1022
	84% CI-upper	469.8	521.5	544.8	640	783.1	1080	1441	1569	1858	2007	2524	3143	4165
6021500.11	estimate	376	433.7	460.7	574.2	745.8	1079	1472	1613	1935	2101	2674	3343	4396
	84% CI-lower	327.6	377.8	401.2	498.8	643.5	912.1	1209	1311	1535	1646	2010	2405	2976
	84% CI-upper	431.6	499	530.8	666	877.8	1325	1924	2157	2727	3039	4209	5751	8549
6022000.10	estimate	499.4	565.9	596.5	722.1	903.9	1236	1604	1731	2013	2154	2624	3147	3925
	84% CI-lower	406.1	460.8	485.8	586.6	728.6	975.7	1229	1312	1489	1574	1839	2109	2470
	84% CI-upper	615	700.3	740.1	908.7	1170	1714	2426	2699	3356	3711	5024	6718	9725
6022000.11	estimate	521.5	592.2	624.8	759.4	956.4	1322	1733	1877	2198	2360	2905	3520	4451
	84% CI-lower	461.9	524.5	553.3	671	839.9	1141	1460	1567	1798	1911	2275	2658	3196
	84% CI-upper	589	670.1	707.8	865.4	1104	1579	2173	2395	2918	3195	4193	5432	7528
6023000.10	estimate	648.2	709.7	737	844	986.6	1220	1447	1520	1674	1748	1977	2209	2523
	84% CI-lower	554.2	608.6	632.6	725.1	845.6	1035	1208	1260	1366	1414	1556	1686	1843
	84% CI-upper	755.2	827.9	860.7	992.2	1178	1519	1903	2037	2337	2488	2996	3571	4452
6023000.11	estimate	679.8	762.9	801	956.8	1181	1590	2042	2198	2544	2718	3298	3945	4915
	84% CI-lower	609	683.3	717.2	854.7	1049	1389	1744	1861	2114	2237	2631	3043	3618
	84% CI-upper	759.2	853.7	897.3	1078	1347	1874	2518	2755	3311	3603	4645	5920	8044
6026500.10	estimate	8623	9162	9396	10280	11390	13080	14600	15070	16020	16460	17790	19060	20690
	84% CI-lower	7024	7881	8221	9328	10430	11860	13060	13420	14130	14450	15380	16240	17270
	84% CI-upper	9363	9982	10260	11320	12700	15010	17410	18210	19910	20740	23350	26050	29750
6026500.11	estimate	8434	8992	9233	10140	11280	12990	14520	14990	15930	16360	17650	18880	20420
	84% CI-lower	7291	8042	8349	9391	10500	11990	13240	13610	14350	14680	15630	16490	17510
	84% CI-upper	9038	9644	9912	10940	12280	14460	16620	17310	18770	19460	21600	23750	26630
6026500.20	estimate	8131	8802	9095	10210	11620	13760	15690	16280	17480	18030	19670	21230	23180
	84% CI-lower	7370	8059	8349	9411	10700	12610	14260	14750	15710	16140	17370	18460	19730
	84% CI-upper	8830	9560	9881	11110	12710	15270	17740	18540	20220	21030	23600	26280	30040
6026500.21	estimate	8259	8882	9153	10180	11470	13430	15190	15720	16810	17310	18810	20230	22020
	84% CI-lower	7701	8348	8620	9615	10820	12610	14160	14620	15530	15940	17120	18180	19420
	84% CI-upper	8749	9408	9697	10800	12220	14440	16540	17210	18600	19270	21370	23520	26490
6036650.10	estimate	8223	8958	9283	10540	12200	14860	17400	18210	19890	20690	23150	25610	28860
	84% CI-lower	6331	7372	7815	9354	11000	13240	15240	15860	17110	17690	19410	21050	23090
	84% CI-upper	9053	9869	10240	11710	13730	17260	21130	22450	25350	26780	31420	36390	43480
6036650.11	estimate	9304	9954	10240	11330	12720	14880	16890	17520	18810	19410	21260	23060	25410
	84% CI-lower	7879	8786	9159	10430	11770	13620	15240	15730	16720	17170	18500	19760	21300
	84% CI-upper	9996	10710	11030	12290	13960	16760	19640	20580	22610	23580	26680	29900	34400
6036650.20	estimate	8486	9220	9543	10790	12400	14930	17300	18040	19570	20290	22470	24610	27390
	84% CI-lower	7677	8459	8789	9997	11480	13720	15740	16360	17600	18170	19850	21400	23290
	84% CI-upper	9150	9945	10300	11670	13490	16480	19470	20440	22540	23560	26870	30410	35510
6036650.21	estimate	9045	9746	10050	11220	12720	15040	17170	17830	19190	19820	21730	23580	25970
	84% CI-lower	8409	9141	9450	10580	11970	14060	15920	16480	17610	18130	19630	21010	22680
	84% CI-upper	9594	10340	10670	11940	13600	16250	18830	19660	21440	22300	25050	27950	32040
6037500.00	estimate	1356	1427	1458	1576	1729	1969	2195	2266	2415	2485	2701	2918	3207
	84% CI-lower	1296	1364	1393	1506	1648	1866	2062	2122	2244	2300	2469	2631	2836
	84% CI-upper	1418	1493	1526	1653	1821	2099	2382	2475	2677	2775	3089	3421	3890
6038500.10	estimate	2302	2428	2484	2697	2975	3420	3847	3983	4269	4405	4830	5261	5845
	84% CI-lower	2167	2285	2336	2534	2787	3175	3528	3635	3856	3958	4264	4558	4934
	84% CI-upper	2447	2584	2645	2883	3207	3771	4382	4592	5055	5287	6053	6901	8162
6038800.10	estimate	2667	2865	2953	3293	3740	4461	5159	5382	5851	6074	6772	7479	8435
	84% CI-lower	2403	2584	2663	2968	3360	3969	4522	4689	5027	5181	5636	6059	6581
	84% CI-upper	2960	3184	3284	3680	4229	5220	6336	6725	7594	8032	9505	11170	13720
6038800.11	estimate	2824	3020	3106	3438	3869	4553	5202	5407	5835	6037	6663	7289	8123
	84% CI-lower	2617	2800	2880	3187	3578	4178	4716	4878	5205	5354	5791	6199	6698
	84% CI-upper	3048	3261	3356	3723	4219	5074	5983	6290	6960	7290	8368	9536	11230
6040000.10	estimate	4290	4648	4805	5412	6203	7455	8637	9009	9781	10140	11260	12360	13810
	84% CI-lower	3517	3834	3971	4491	5147	6142	7019	7279	7793	8022	8678	9261	9938
	84% CI-upper	5173	5617	5817	6620	7761	9855	12190	13000	14790	15690	18690	22040	27130
6040000.11	estimate	4351	4669	4808	5338	6011	7047	7995	8287	8887	9165	10010	10820	11870
	84% CI-lower	4012	4312	4443	4936	5555	6479	7278	7511	7971	8174	8755	9270	9869
	84% CI-upper	4711	5054	5205	5783	6543	7801	9068	9481	10360	10790	12130	13530	15490
6041000.10	estimate	4757	5064	5197	5701	6333	7290	8151	8415	8951	9199	9944	10660	11560
	84% CI-lower	4425	4717	4843	5315	5902	6767	7497	7707	8111	8288	8782	9208	9693
	84% CI-upper	5113	5440	5582	6124	6825	7979	9131	9502	10290	10670	11860	13080	14780
6042500.11	estimate	4813	5131	5269	5790	6446	7437	8331	8604	9160	9417	10190	10930	11860
	84% CI-lower	4470	4771	4902	5391	5998	6895	7654	7871	8290	8472	8981	9419	9915
	84% CI-upper	5182	5521	5668	6229	6956	8155	9354	9741	10560	10950	12190	13470	15240

Streamgage identification number and analysis designation[1]	Streamgage name	1%plus	(A) 1% est.	(B) upper 84% CI	N	These data from table 1-6; to adj. MOVE3 1%plus at-site	ne	(C) CI adj factor	(D) Diff. (A)-(B)	(E) adjusted diff. (C)*(D)	(F) Adj. 1%plus (A)+(E)
06018500.10	Beaverhead River near Twin Bridges, Montana										
06019500.00	Ruby River above reservoir, near Alder, Montana	3,800	2702	3800							
06020600.11	Ruby River below reservoir, near Alder, Montana	3,210	2387	3078	78	54	11.48	1.19	691	823	3210
06021500.11	Ruby River at Laurin, Montana	5,940	2674	4209	78	14	22.68	2.13	1535	3265	5939
06022000.11	Ruby River below Ramshorn Creek, near Sheridan, Montana	5,310	2905	4193	78	26	15.81	1.87	1288	2403	5308
06023000.11	Ruby River near Twin Bridges, Montana	6,020	3298	4645	78	25	13.57	2.02	1347	2724	6022
06026500.21	Jefferson River near Twin Bridges, Montana	21,500	18810	21370	111	64	41.55	1.05	2560	2692	21502
06036650.21	Jefferson River near Three Forks, Montana	25,100	21730	25050	111	80	27.85	1.03	3320	3417	25147
06037500.00	Madison River near West Yellowstone, Montana	3,090	2701	3089							
06038500.10	Madison River below Hebgen Lake, near Grayling, Montana	6,050	4830	6053							
06038800.11	Madison River at Kirby Ranch, near Cameron, Montana	8,760	6663	8368	57	35	11.37	1.23	1705	2096	8759
06040000.11	Madison River near Cameron, Montana	12,800	10010	12130	57	13	30.01	1.33	2120	2809	12819
06041000.10	Madison River below Ennis Lake, near McAllister, Montana	11,900	9944	11860							
06042500.11	Madison River near Three Forks, Montana	13,100	10190	12190	57	0	39.76	1.43	2000	2867	13057

Appendix C.

Ungaged Site Analysis

Gage Transfer

Regression Equations

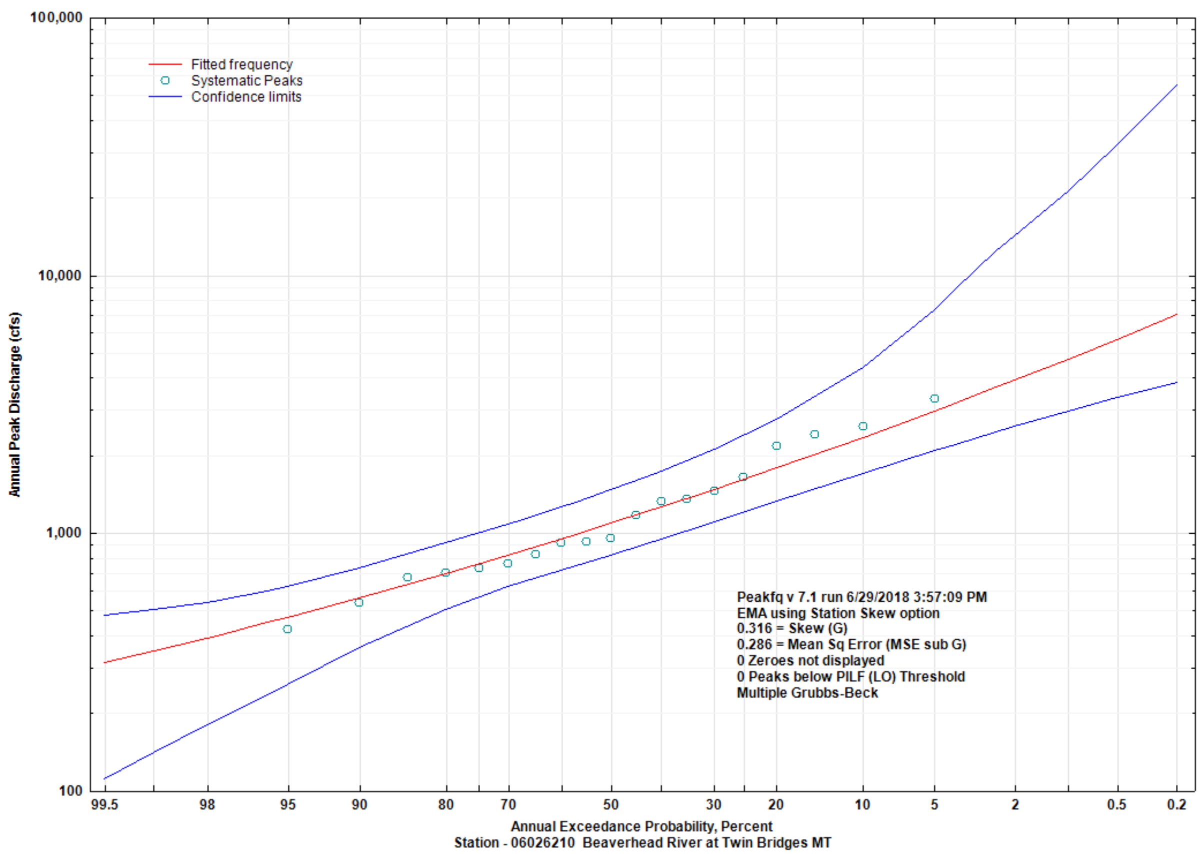
Twin Bridges Reach of the Beaverhead River

		Drainage Area Transfer Coefficient:			0.755		0.69		0.647		0.609		0.533		0.609		
Node ID	Station Number	Station Name	Drainage Area (mi^2)	log DA	Q_{10} (cfs)	log(Q_{10})	Q_4 (cfs)	log(Q_4)	Q_2 (cfs)	log(Q_2)	Q_1 (cfs)	log(Q_1)	$Q_{0.2}$ (cfs)	log($Q_{0.2}$)	$Q_{1'plus'}$ (cfs)	log($Q_{1'plus'}$)	DA ratio
Jefferson																	
8	100	Jefferson River Confluence with Madison	9,629	3.9836	15,088		17,896		19,900		21,803		26,108		25,219		1.01
9	06036650	Jefferson River near Three Forks, MT	9,554	3.9802	15,000	4.1761	17,800	4.2504	19,800	4.2967	21,700	4.3365	26,000	4.41497	25,100	4.3996737	
10	200	Jefferson River above Willow Cr	9,300	3.9685	14,801	4.1703	17,537	4.244	19,486	4.2897	21,334	4.3291	25,490	4.40637	24,643	4.3916999	
11	300	Jefferson River above South Boulder River	8,335	3.9209	14,016	4.1466	16,505	4.2176	18,256	4.2614	19,906	4.299	23,515	4.37134	22,868	4.3592348	
1	400	Jefferson River above Fish Creek	7,832	3.8939	13,590	4.1332	15,948	4.2027	17,594	4.2454	19,139	4.2819	22,463	4.35147	21,919	4.3408257	
3	060265000	Jefferson River near Twin Bridges, MT	7,614	3.8816	13,400	4.1271	15,700	4.1959	17,300	4.238	18,800	4.2742	22,000	4.34242	21,500	4.3324385	
Beaverhead																	
4	06023100	Beaverhead River at Twin Bridges, MT	4,782		1,604		1,963		2,239		2,512		3,167		3,353		1.32
5	600	Beaverhead River Confluence with Ruby River	3,782		1,344		1,670		1,924		2,177		2,795		2,907		1.04
7	06018500	Beaverhead River near Twin Bridges	3,620		1,300		1,620		1,870		2,120		2,730		2830		

						South Boulder River at Confluence with Jefferson River (700)			South Boulder River at Canyon (800)			Indian Creek at Sheridan, MT (1000)			Indian Creek at Confluence with Wisconsin Cr near Ruby River (900)			Mill Creek at Sheridan, MT (1200)			Mill Creek at Confluence with Ruby River (1100)		
$Q_i = a1\ A^{a2} (E_{6000} + 1)^{a3}$	i	$a1$	$a2$	$a3$	SEP	A (mi^2)	E_{6000} (%)	Q (cfs)	A (mi^2)	E_{6000} (%)	Q (cfs)	A (mi^2)	E_{6000} (%)	Q (cfs)	A (mi^2)	E_{6000} (%)	Q (cfs)	A (mi^2)	E_{6000} (%)	Q (cfs)	A (mi^2)	E_{6000} (%)	Q (cfs)
$Q_{10} = 31.9\ A^{0.796} (E_{6000} + 1)^{-0.177}$	10	31.9	0.796	-0.177		79.8	67.3	493	62.7	85.7	390	14.4	93.9	119	26.5	54.0	213	29.6	88.8	213	39.4	69.9	279
$Q_4 = 79.8\ A^{0.750} (E_{6000} + 1)^{-0.274}$	4	79.8	0.75	-0.274		79.8	67.3	670	62.7	85.7	524	14.4	93.9	169	26.5	54.0	311	29.6	88.8	295	39.4	69.9	390
$Q_2 = 142\ A^{0.721} (E_{6000} + 1)^{-0.336}$	2	142	0.721	-0.336		79.8	67.3	808	62.7	85.7	627	14.4	93.9	210	26.5	54.0	392	29.6	88.8	360	39.4	69.9	479
$Q_1 = 238\ A^{0.696} (E_{6000} + 1)^{-0.391}$	1	238	0.696	-0.391		79.8	67.3	962	62.7	85.7	741	14.4	93.9	257	26.5	54.0	486	29.6	88.8	433	39.4	69.9	580
$Q_{0.2} = 655\ A^{0.649} (E_{6000} + 1)^{-0.501}$	0.2	655	0.649	-0.501		79.8	67.3	1,354	62.7	85.7	1,028	14.4	93.9	378	26.5	54.0	738	29.6	88.8	620	39.4	69.9	840
$Q_{1\%plus'} = Q1 + SEP\ Q1$					73.8%			1,672			1,288			446			845			753			1,008

Twin Bridges Reach of the Beaverhead River

```
Z06026210                    USGS
H06026210       452624112332100303005 7SW100200042668          4850
N06026210       Beaverhead River at Twin Bridges MT
Y06026210
306026210       19980627   3312                5.18
306026210       19990530   1647                6.15
306026210       20000529    919                3.99
306026210       20010606    955               3.90
306026210       20020603    536                5.46
306026210       20030531    764                7.05
306026210       20040612    425                3.84
306026210       20050521   1177                4.48
306026210       20060521   2177                5.80
306026210       20070609    704                4.73
306026210       20080522    927                6.36
306026210       20090601   1463                6.43
306026210       20100618   2584                7.16
306026210       20110610   2408                7.63
306026210       20120427   1357                5.55
306026210       20130403    729                4.26
306026210       20140529   1329                6.46
306026210       20150603    671                4.68
306026210       20160522    823                5.00
```



```
1
  Program PeakFq           U. S. GEOLOGICAL SURVEY             Seq.002.000
  Version 7.1        Annual peak flow frequency analysis      Run Date /
Time
  3/14/2014                                                    06/29/2018
15:57

                         --- PROCESSING OPTIONS ---

                      Plot option          = Graphics device
                      Basin char output    = None
                      Print option         = Yes
                      Debug print          = No
                      Input peaks listing = Long
                      Input peaks format   = WATSTORE peak file

                      Input files used:
                         peaks (ascii)  -
P:\SPECIALS\WOT\Montana\Madison\06023100.TXT
                         specifications -
P:\SPECIALS\WOT\Montana\Madison\PKFQWPSF.TMP
                      Output file(s):
                         main - P:\SPECIALS\WOT\Montana\Madison\06023100.PRT

1


  Program PeakFq           U. S. GEOLOGICAL SURVEY             Seq.001.001
  Version 7.1        Annual peak flow frequency analysis      Run Date /
Time
  3/14/2014                                                    06/29/2018
15:57

            Station - 06026210  Beaverhead River at Twin Bridges MT


                     I N P U T   D A T A   S U M M A R Y

                Number of peaks in record            =       19
                Peaks not used in analysis           =        0
                Systematic peaks in analysis         =       19
                Historic peaks in analysis           =        0
                Beginning Year                       =     1998
                Ending Year                          =     2016
                Historical Period Length             =       19
                Generalized skew                     =   -0.195
                     Standard error                  =    0.550
                     Mean Square error               =    0.303
                Skew option                          = STATION SKEW
                Gage base discharge                  =      0.0
                User supplied high outlier threshold =   --
                User supplied PILF (LO) criterion    =   --
                Plotting position parameter          =     0.00
                Type of analysis                             EMA
                PILF (LO) Test Method                       MGBT
```

```
                Perception Thresholds:
                     Begin      End        Low      High     Comment
                      1998     2016        0.0        INF      DEFAULT
                Interval Data                         =   None Specified


  *********  NOTICE  --  Preliminary machine computations.        *********
  *********  User responsible for assessment and interpretation.  *********

   *WCF151I-17B WEIGHTED SKEW REPLACED BY USER OPTION.     0.068     0.316  -
1
    WCF002J-CALCS COMPLETED.  RETURN CODE =  2
    EMA002W-CONFIDENCE INTERVALS ARE NOT EXACT IF HISTORIC PERIOD > 0


                                                    Kendall's Tau Parameters

                                                                MEDIAN   No. of
                                                   TAU    P-VALUE    SLOPE   PEAKS
                                            ---------------------------------------
                         SYSTEMATIC RECORD     -0.076      0.675    -13.000    19


1


  Program PeakFq           U. S. GEOLOGICAL SURVEY              Seq.001.002
  Version 7.1         Annual peak flow frequency analysis       Run Date /
Time
  3/14/2014                                                     06/29/2018
15:57

            Station - 06026210  Beaverhead River at Twin Bridges MT


           ANNUAL FREQUENCY CURVE PARAMETERS -- LOG-PEARSON TYPE III

                                               LOGARITHMIC
                                     -------------------------------
                                                 STANDARD
                                        MEAN     DEVIATION     SKEW
                                     -------------------------------
 EMA W/O REG. INFO           3.0507      0.2439      0.316
 EMA W/REG. INFO             3.0507      0.2439      0.316

 EMA ESTIMATE OF MSE OF SKEW W/O REG. INFO (AT-SITE)      0.2859
 EMA ESTIMATE OF MSE OF SKEW W/SYSTEMATIC ONLY (AT-SITE)  0.2859



    ANNUAL FREQUENCY CURVE -- DISCHARGES AT SELECTED EXCEEDANCE PROBABILITIES

   ANNUAL    EMA W/    EMA W/O     <------ FOR EMA ESTIMATES ------->
EXCEEDANCE  REG INFO  REG INFO    VARIANCE  95% CONFIDENCE INTERVALS
```

PROBABILITY	ESTIMATE	ESTIMATE	OF EST.	LOWER	UPPER
0.9950	312.5	312.5	0.0173	111.2	481.4
0.9900	347.2	347.2	0.0128	141.1	504.2
0.9500	470.6	470.6	0.0058	257.7	619.5
0.9000	559.3	559.3	0.0042	357.5	732.1
0.8000	696.1	696.1	0.0035	506.8	917.2
0.6667	862.4	862.4	0.0034	650.4	1139.0
0.5000	1091.	1091.	0.0036	821.1	1467.0
0.4292	1207.	1207.	0.0037	905.5	1647.0
0.2000	1784.	1784.	0.0050	1326.0	2748.0
0.1000	2346.	2346.	0.0071	1706.0	4371.0
0.0400	3185.	3185.	0.0120	2206.0	8867.0
0.0200	3908.	3908.	0.0174	2584.0	14150.0
0.0100	4722.	4722.	0.0244	2964.0	21290.0
0.0050	5637.	5637.	0.0332	3344.0	32060.0
0.0020	7026.	7026.	0.0474	3853.0	54750.0

1

Program PeakFq U. S. GEOLOGICAL SURVEY Seq.001.003
Version 7.1 Annual peak flow frequency analysis Run Date / Time
3/14/2014 06/29/2018 15:57

Station - 06026210 Beaverhead River at Twin Bridges MT

I N P U T D A T A L I S T I N G

WATER YEAR	PEAK VALUE	PEAKFQ CODES	<--- Intervals ---> LOW	HIGH	REMARKS
1998	3312.0				
1999	1647.0				
2000	919.0				
2001	955.0				
2002	536.0				
2003	764.0				
2004	425.0				
2005	1177.0				
2006	2177.0				
2007	704.0				
2008	927.0				
2009	1463.0				
2010	2584.0				
2011	2408.0				
2012	1357.0				
2013	729.0				
2014	1329.0				
2015	671.0				
2016	823.0				

```
       Explanation of peak discharge qualification codes

      PeakFQ    NWIS
       CODE     CODE   DEFINITION

         D        3    Dam failure, non-recurrent flow anomaly
         G        8    Discharge greater than stated value
         X       3+8   Both of the above
         L        4    Discharge less than stated value
         K      6 OR C  Known effect of regulation or urbanization
         H        7    Historic peak

         -  Minus-flagged discharge -- Not used in computation
               -8888.0 -- No discharge value given
         -  Minus-flagged water year -- Historic peak used in computation
```

1

```
  Program PeakFq            U. S. GEOLOGICAL SURVEY            Seq.001.004
  Version 7.1           Annual peak flow frequency analysis      Run Date /
Time
  3/14/2014                                                    06/29/2018
15:57

            Station - 06026210  Beaverhead River at Twin Bridges MT


   EMPIRICAL FREQUENCY CURVES -- HIRSCH-STEDINGER PLOTTING POSITIONS

   WATER     RANKED      EMA          INTERVALS
    YEAR   DISCHARGE   ESTIMATE      LOW      HIGH
    1998     3312.0     0.0498
    2010     2584.0     0.0998
    2011     2408.0     0.1498
    2006     2177.0     0.1999
    1999     1647.0     0.2499
    2009     1463.0     0.2999
    2012     1357.0     0.3499
    2014     1329.0     0.4000
    2005     1177.0     0.4500
    2001      955.0     0.5000
    2008      927.0     0.5500
    2000      919.0     0.6000
    2016      823.0     0.6501
    2003      764.0     0.7001
    2013      729.0     0.7501
    2007      704.0     0.8001
    2015      671.0     0.8502
    2002      536.0     0.9002
    2004      425.0     0.9502
```

1

```
  Program PeakFq           U. S. GEOLOGICAL SURVEY             Seq.001.005
  Version 7.1        Annual peak flow frequency analysis      Run Date /
Time
  3/14/2014                                                    06/29/2018
15:57

            Station - 06026210  Beaverhead River at Twin Bridges MT


                         EMA REPRESENTATION OF DATA

  WATER <----- OBSERVED-----><-------- EMA -------><-PERCEPTION THRESHOLDS->
   YEAR    Q_LOWER    Q_UPPER    Q_LOWER    Q_UPPER        LOWER       UPPER
   1998     3312.0     3312.0     3312.0     3312.0          0.0         INF
   1999     1647.0     1647.0     1647.0     1647.0          0.0         INF
   2000      919.0      919.0      919.0      919.0          0.0         INF
   2001      955.0      955.0      955.0      955.0          0.0         INF
   2002      536.0      536.0      536.0      536.0          0.0         INF
   2003      764.0      764.0      764.0      764.0          0.0         INF
   2004      425.0      425.0      425.0      425.0          0.0         INF
   2005     1177.0     1177.0     1177.0     1177.0          0.0         INF
   2006     2177.0     2177.0     2177.0     2177.0          0.0         INF
   2007      704.0      704.0      704.0      704.0          0.0         INF
   2008      927.0      927.0      927.0      927.0          0.0         INF
   2009     1463.0     1463.0     1463.0     1463.0          0.0         INF
   2010     2584.0     2584.0     2584.0     2584.0          0.0         INF
   2011     2408.0     2408.0     2408.0     2408.0          0.0         INF
   2012     1357.0     1357.0     1357.0     1357.0          0.0         INF
   2013      729.0      729.0      729.0      729.0          0.0         INF
   2014     1329.0     1329.0     1329.0     1329.0          0.0         INF
   2015      671.0      671.0      671.0      671.0          0.0         INF
   2016      823.0      823.0      823.0      823.0          0.0         INF
1



 End PeakFQ analysis.
   Stations processed :       1
   Number of errors   :       0
   Stations skipped   :       0
   Station years      :      19


Data records may have been ignored for the stations listed below.
(Card type must be Y, Z, N, H, I, 2, 3, 4,  or *.)
(2, 4, and * records are ignored.)

 For the station below, the following records were ignored:

 FINISHED PROCESSING STATION:  06026210       USGS Beaverhead River at Twin
Brid

 For the station below, the following records were ignored:
FINISHED PROCESSING STATION:
```